

Service Training
MALAGA

CAT Diesel Engines

Thorben
November 1997

Caterpillar produces engines for various applications:

EPG

MARINE

INDUSTRIAL

CAPTIVE

The engines are divided in three categories:

Small engines (3000 - 3300)

Medium engines (3400 - 3500)

Large engines (3600 - MAK)

Caterpillar engines can be divided in two types:

IN-LINE ENGINES

VEE - ENGINES

Those two types of engines are running on two different types of fuel:

GAS

DIESEL

If you know one, you know them all !

The difference from one engine to another is the fuel system.

All other systems (cooling , lubrication , air) are fitted to the different fuel systems.

The fuel system is the heart of an engine. It gives the engine its power.



AIR INTAKE & EXHAUST



LUBRICATION



COOLING



FUEL

Air intake & exhaust

Natural Aspirated

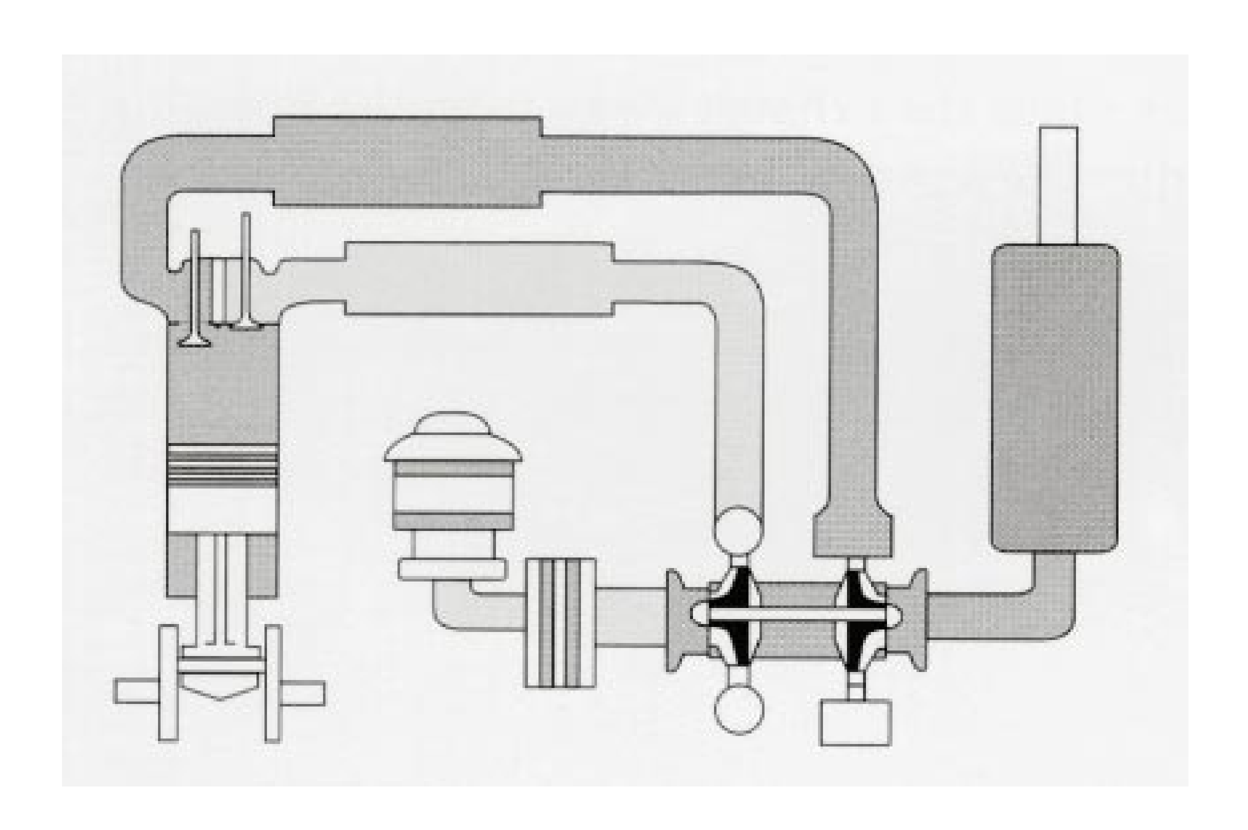
Turbocharged

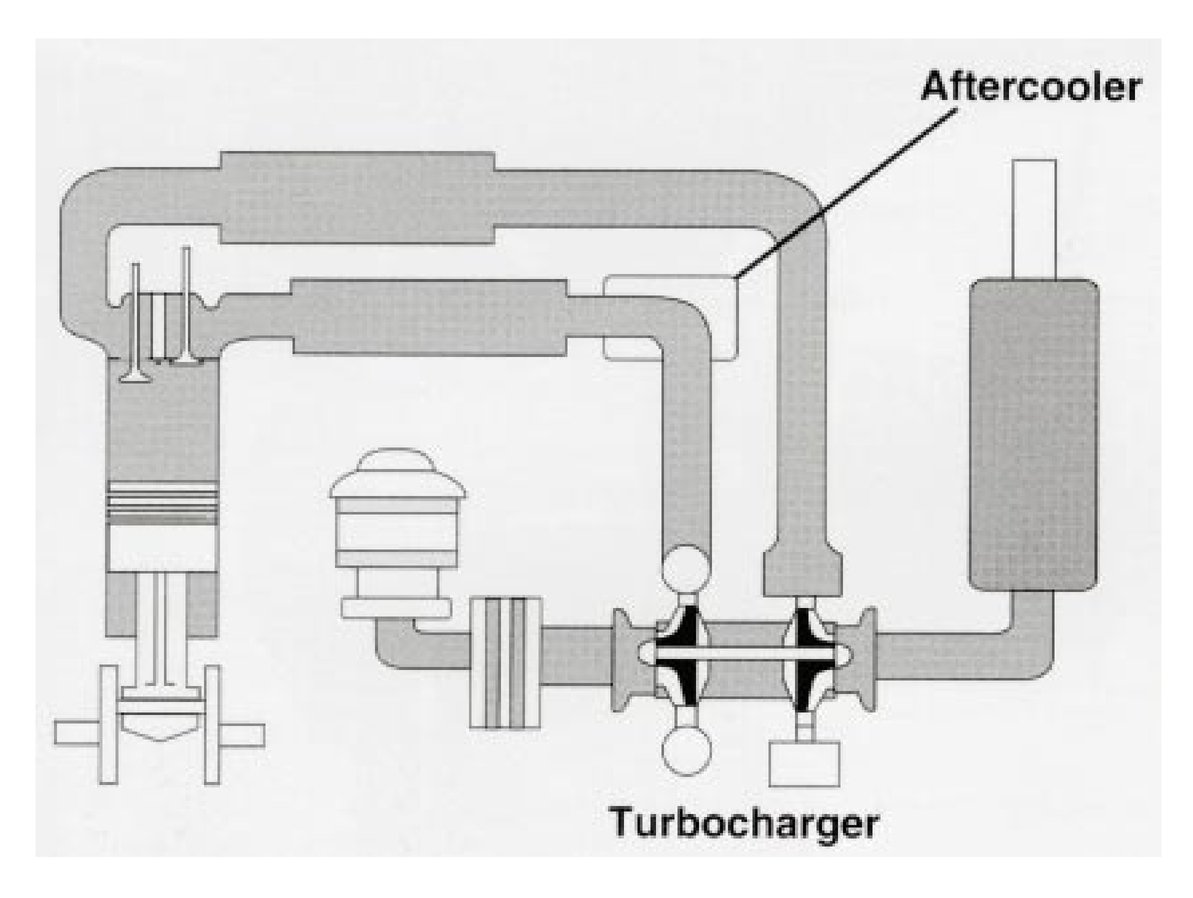
Turbocharged

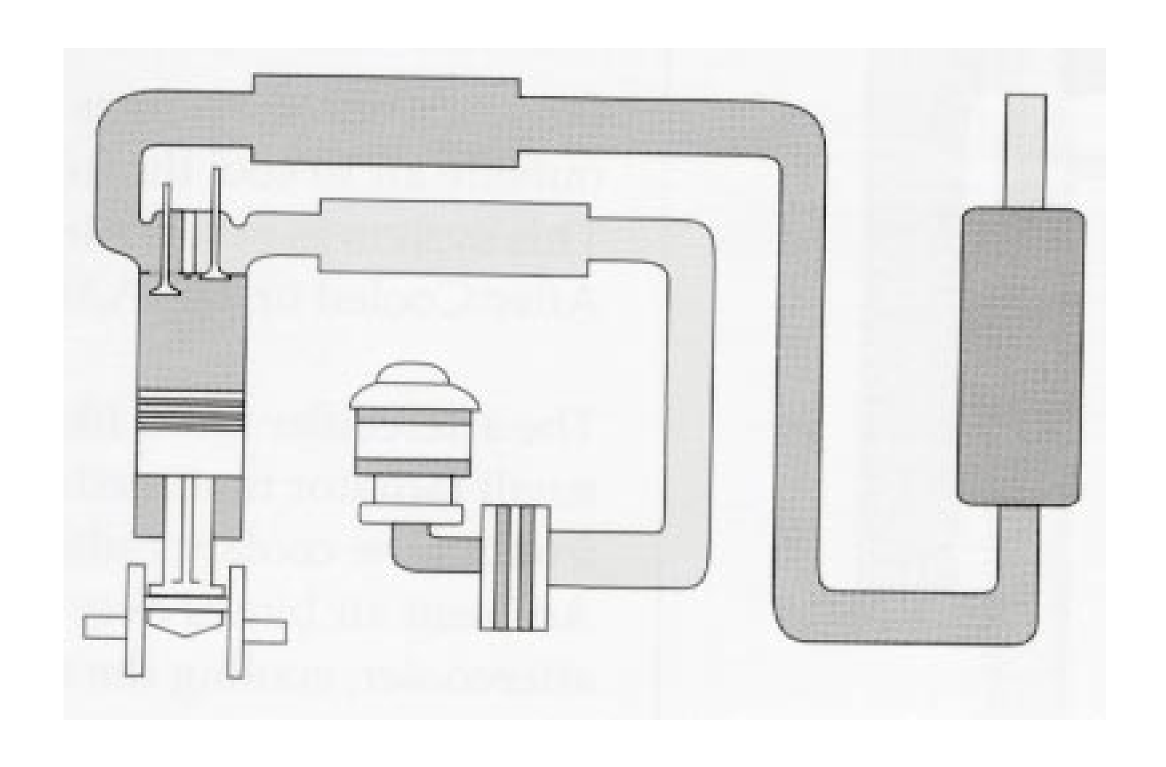
Turbocharged Aftercooled

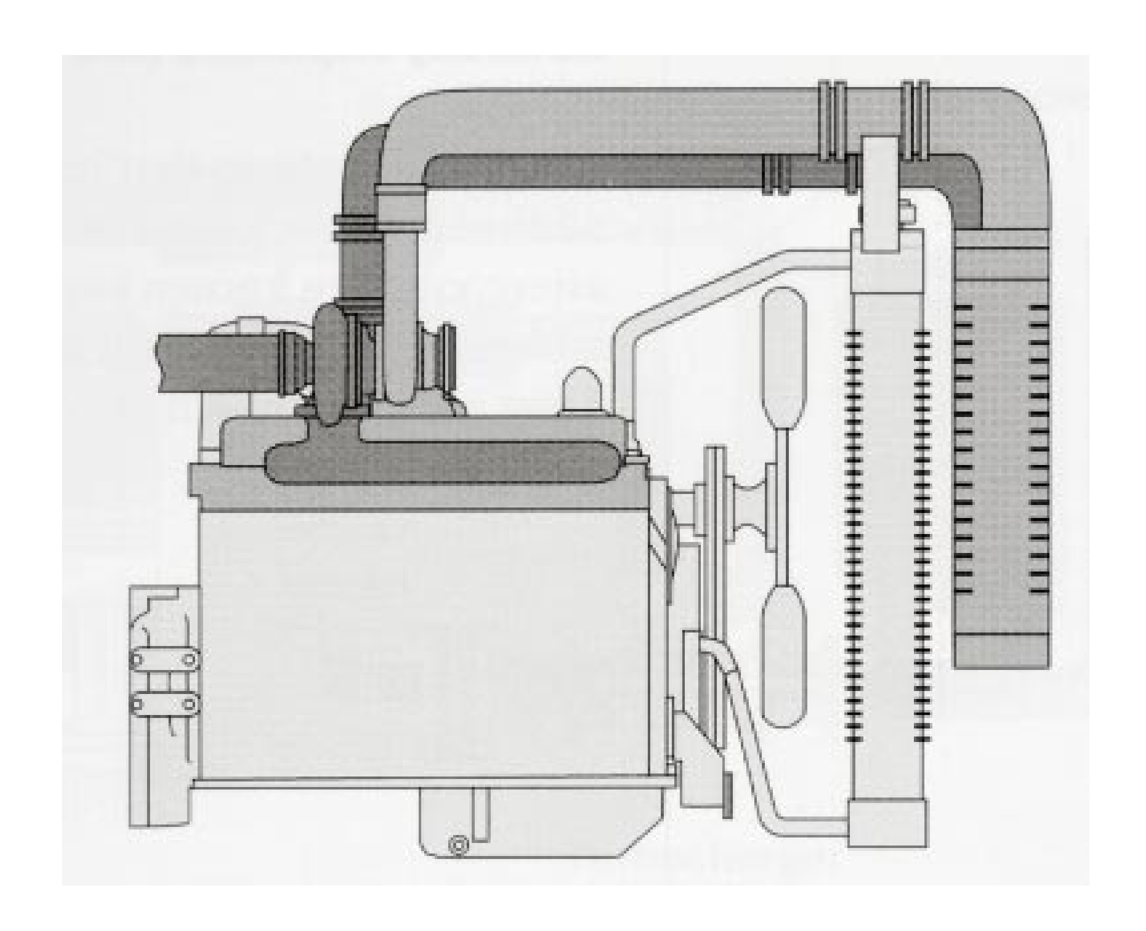
ATAAC

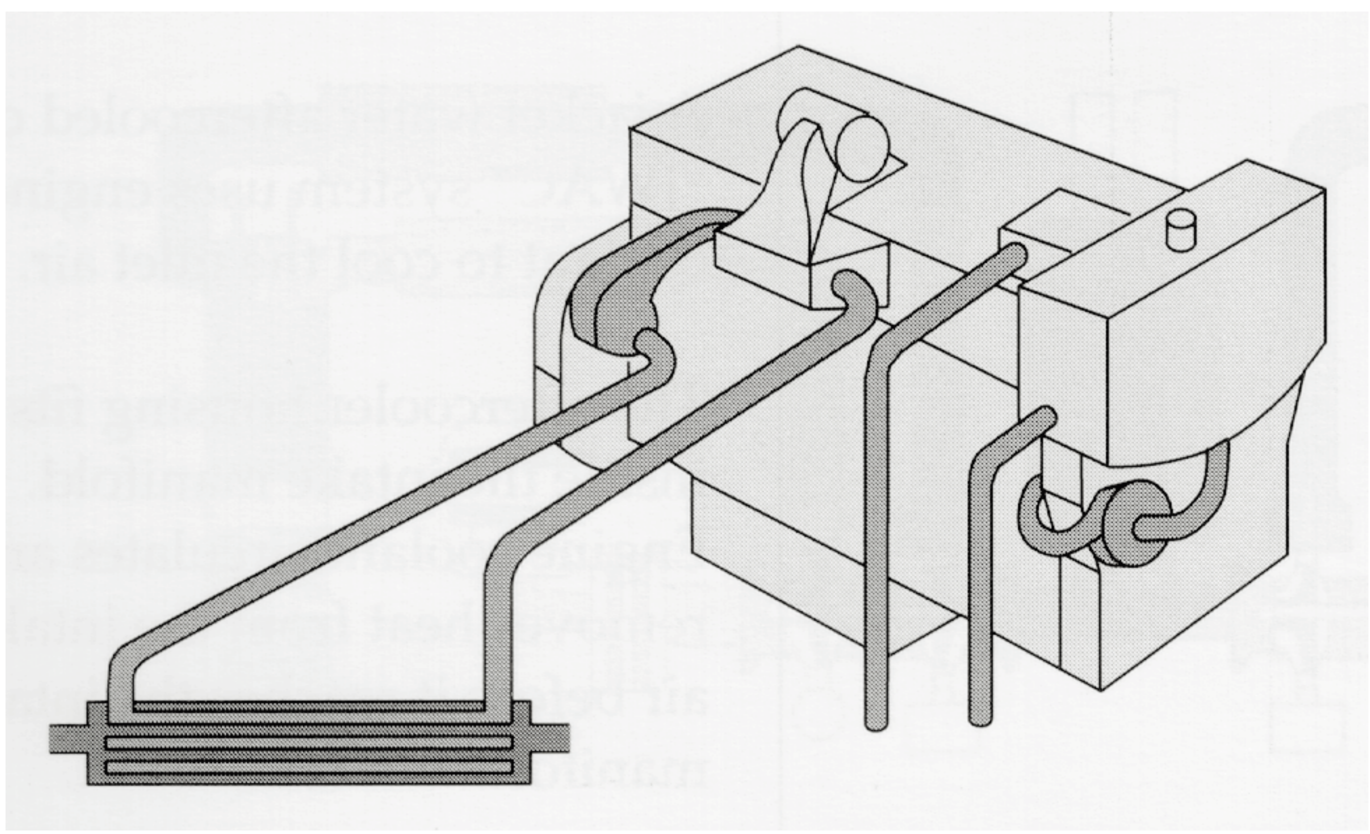
JWAC




Aftercooler
Turbocharger







The use of a turbocharger is to get more power out of an engine.

More air in the cylinder...

More fuel can be burned...

More horsepower output !

Aftercooling is an addition to turbocharging - this increases the horsepower again !!

INTAKE

COMPRESSION

FIRST TURN

POWER

EXHAUST

SECOND TURN

Lubrication system

OIL

An engine oil serves 5 vital functions in a modern diesel engine:

1. **Lubricates friction surfaces by forming a fluid film**

2. **Cools internal engine parts by absorbing heat.**

3. **Cleans the engine by flushing away dirt and wear particles**

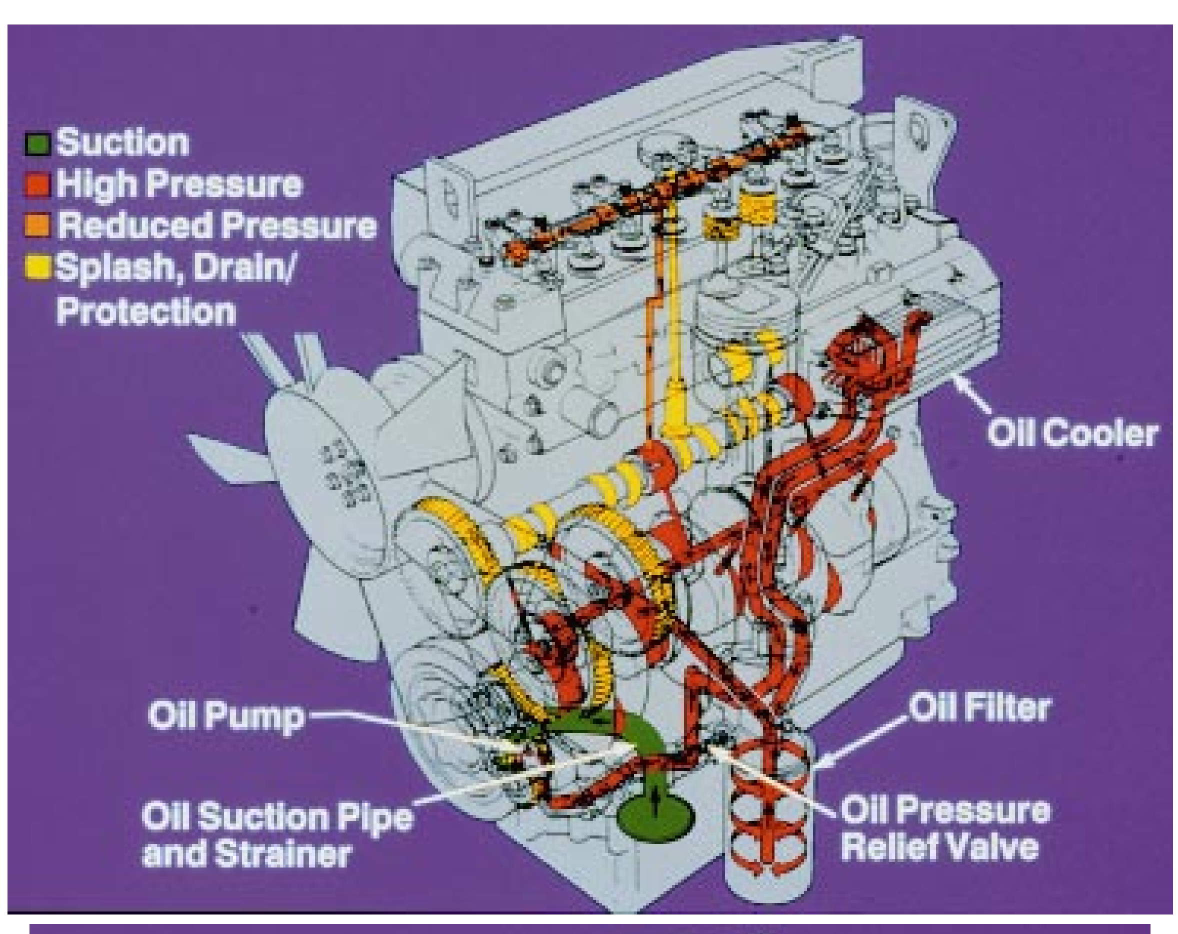
4. **Supprts the crankshaft and bearing**

5. **Protects the engine from harmfull acids, rust and deposits**

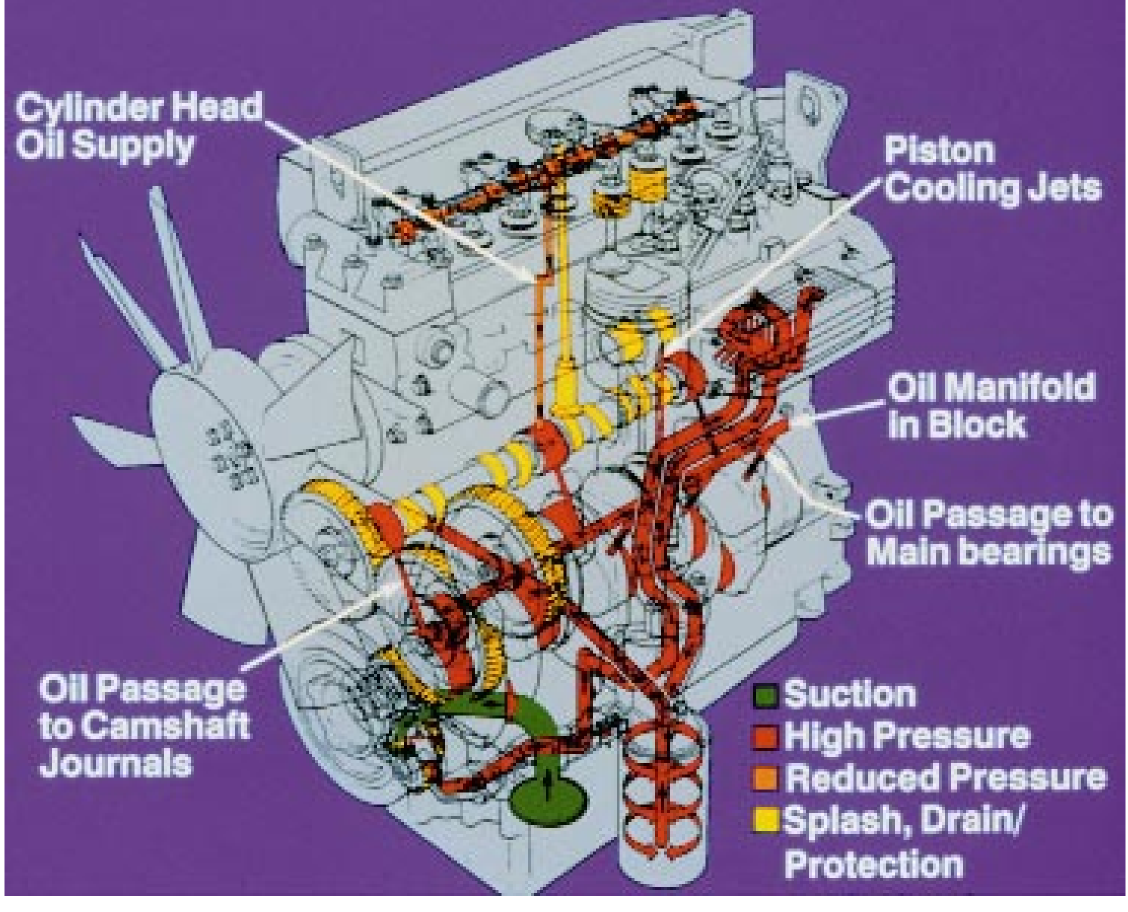
Viscosity

Internal resistance felt as one layer of liquid moves relative to another layer - ie: internal liquid friction.

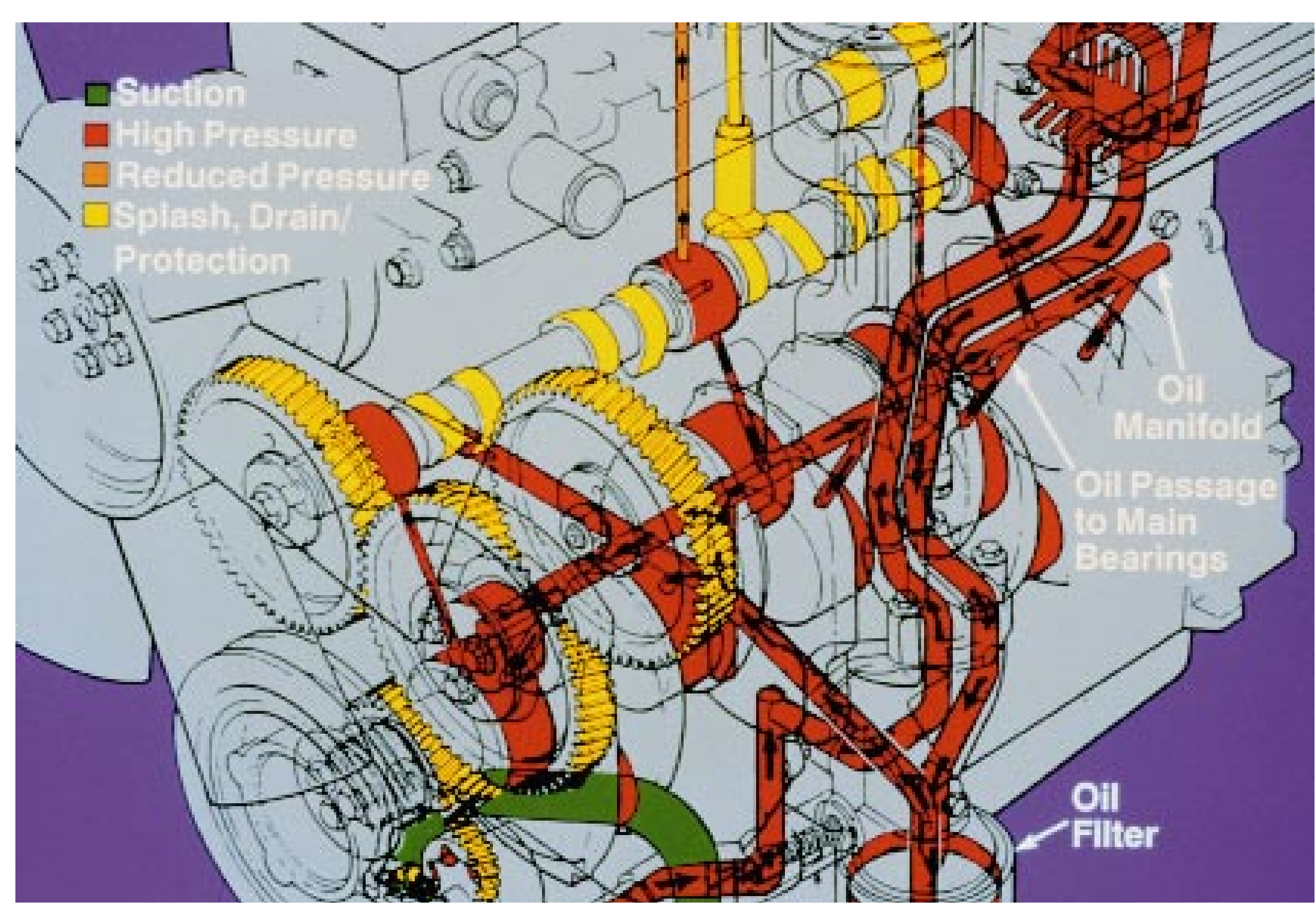
SAE 20	weight 20 at 100C (212F)
SAE 20W	weight 20 at -18C (0F)
SAE 20W - 30	weight 20 at -18C (0F)
	&
	weight 30 at 100C (212F)

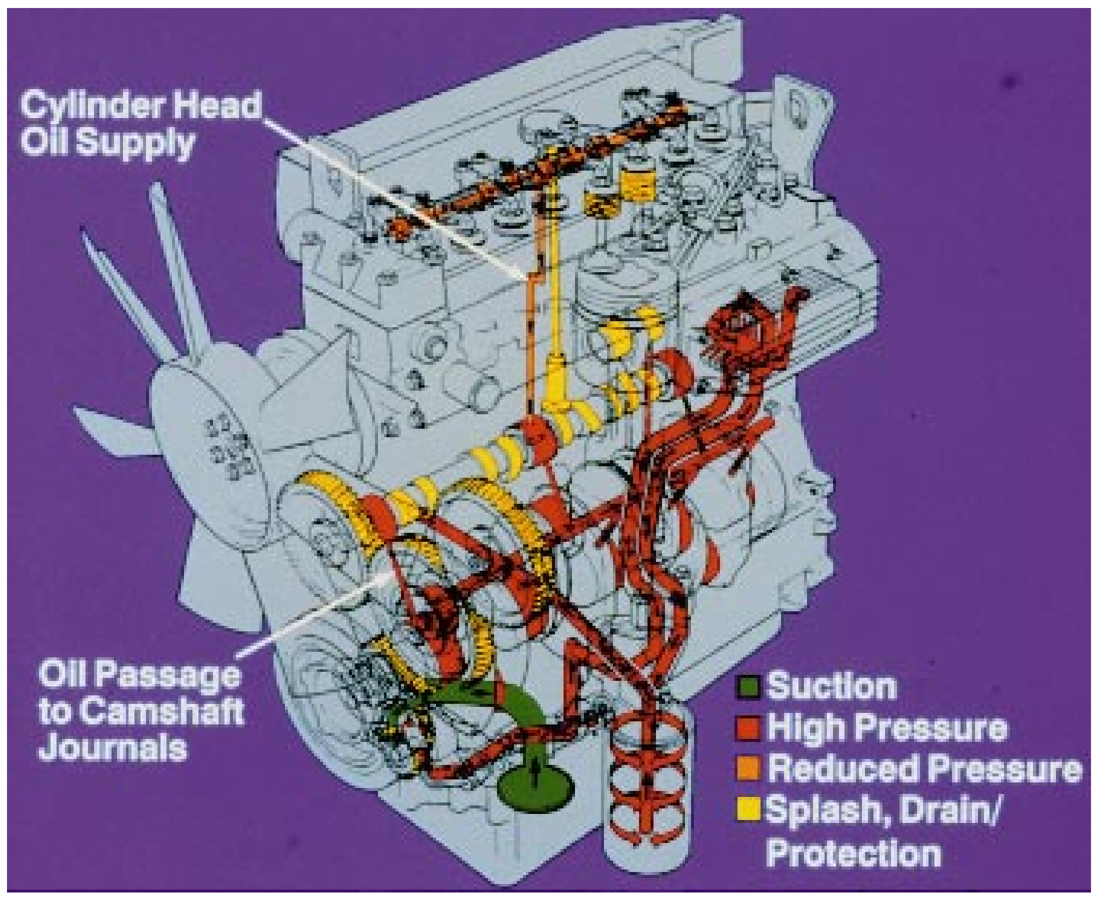


Suction
High Pressure
Reduced Pressure
Splash, Drain/ Protection
Oil Cooler
Oil Pump
Oil Filter
Oil Suction Pipe and Strainer
Oil Pressure Relief Valve



Cylinder Head Oil Supply
Piston Cooling Jets
Oil Manifold in Block
Oil Passage to Main bearings
Oil Passage to Camshaft Journals
Suction
High Pressure
Reduced Pressure
Splash, Drain/ Protection


Suction
High Pressure
Reduced Pressure
Splash, Drain/
Protection
Oil
Manifold
Oil Passage
to Main
Bearings
Oil
Filter


Cylinder Head
Oil Supply
Oil Passage
to Camshaft
Journals
Suction
High Pressure
Reduced Pressure
Splash, Drain/
Protection

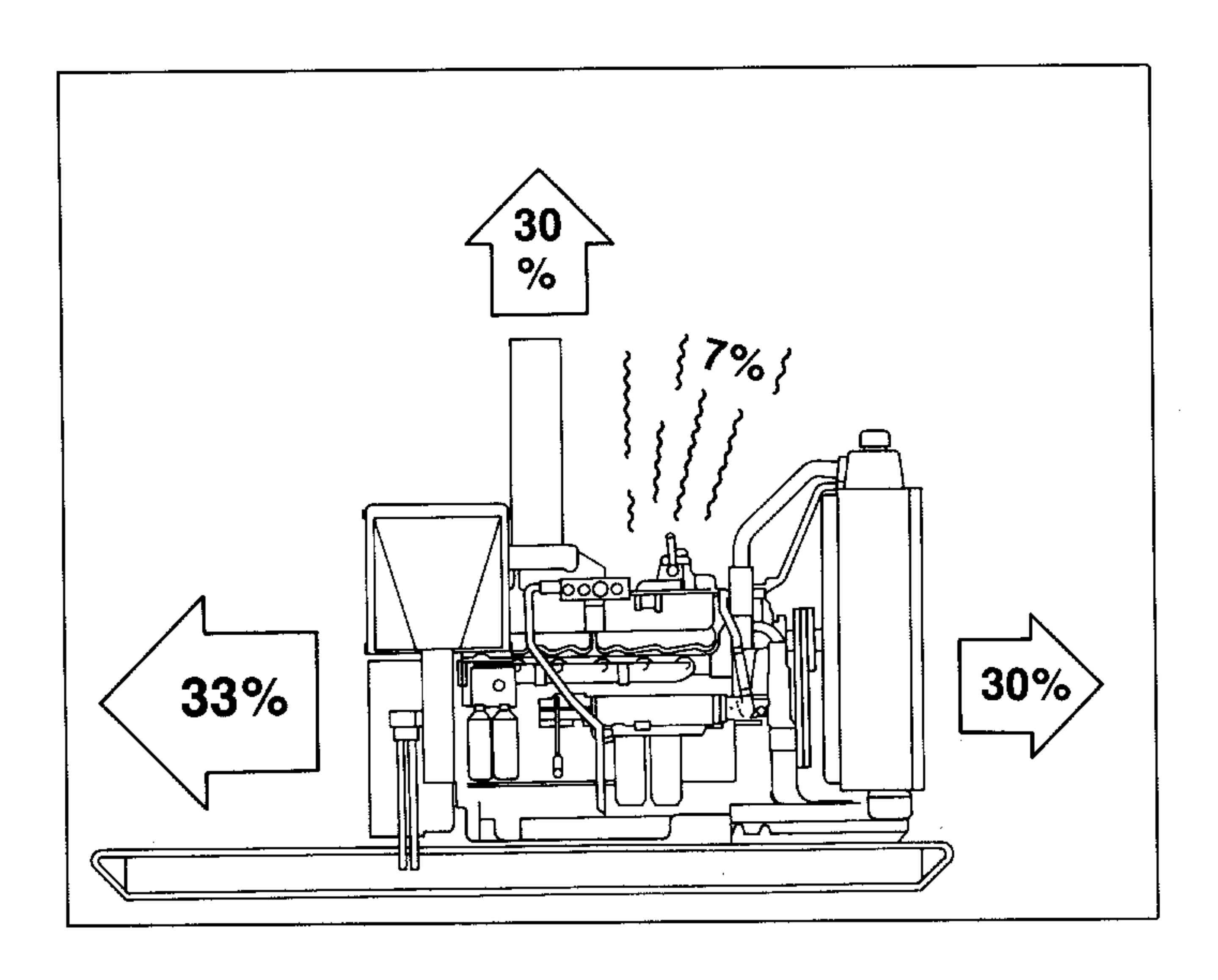
to fuel injection pump housing
rocker arm shaft
turbocharger
to rocker arm shaft
to valve lifters
bore for camshaft
piston cooling tubes
bore for balancer shaft
to timing gear housing
bypass valves for oil filters
oil manifold
bypass valve for oil cooler
oil cooler
oil filters
oil pan
oil pump


CATERPILLAR®

Suction
High Pressure
Reduced Pressure
Splash, Drain/
Protection
Oil Pressure
Relief Valve

Cooling system

Fuel burning temperature can reach 1927C (3500F).



Other heat gernerating sources:

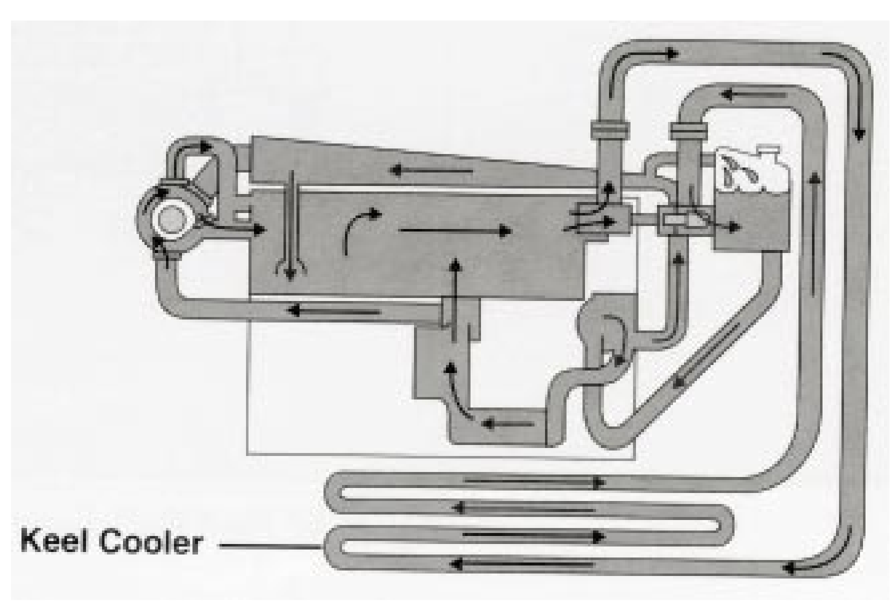
- transmission oil coolers
- hydraulic oil coolers
- aftercoolers
- water-cooled exhaust manifolds
- water-cooled turbocharger shields and housings
- marine gear oil coolers
- torque converter / retarder coolers

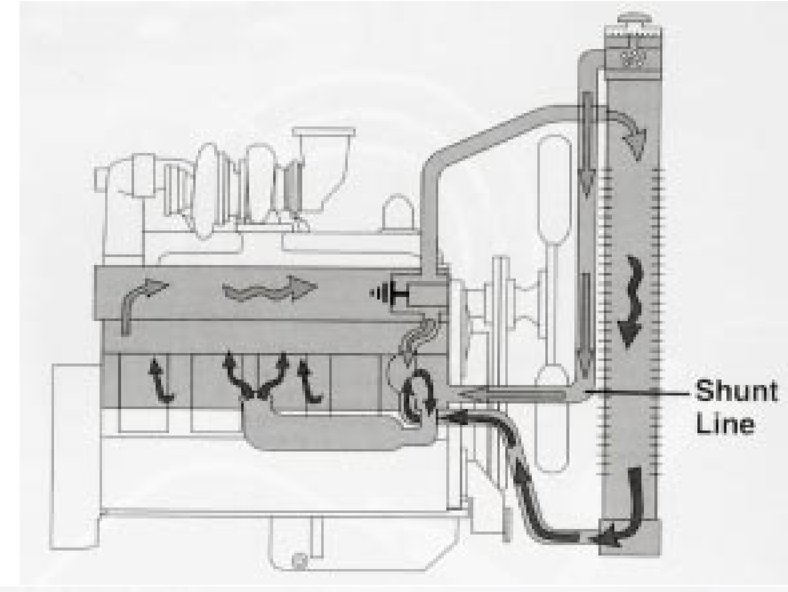
Cooling systems:

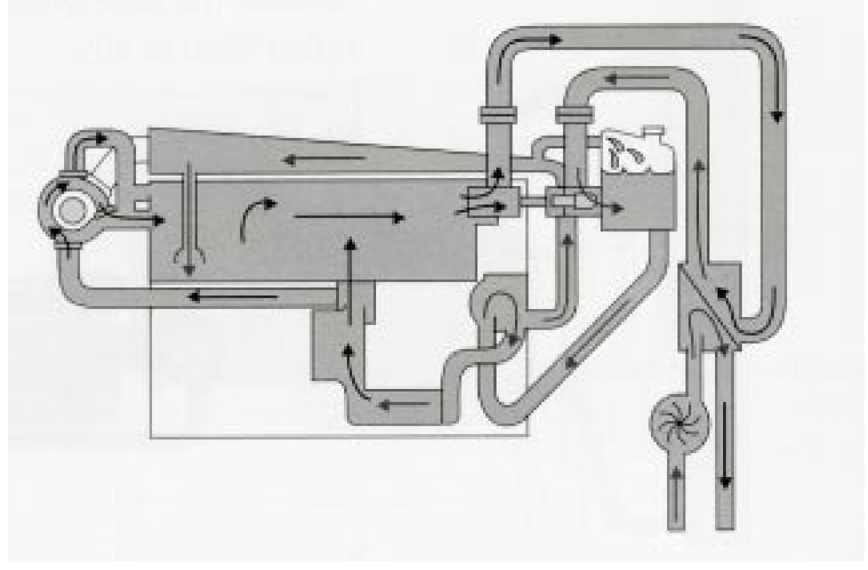
- radiator
- keel cooler
- shunt cooling
- heat exchanger cooling

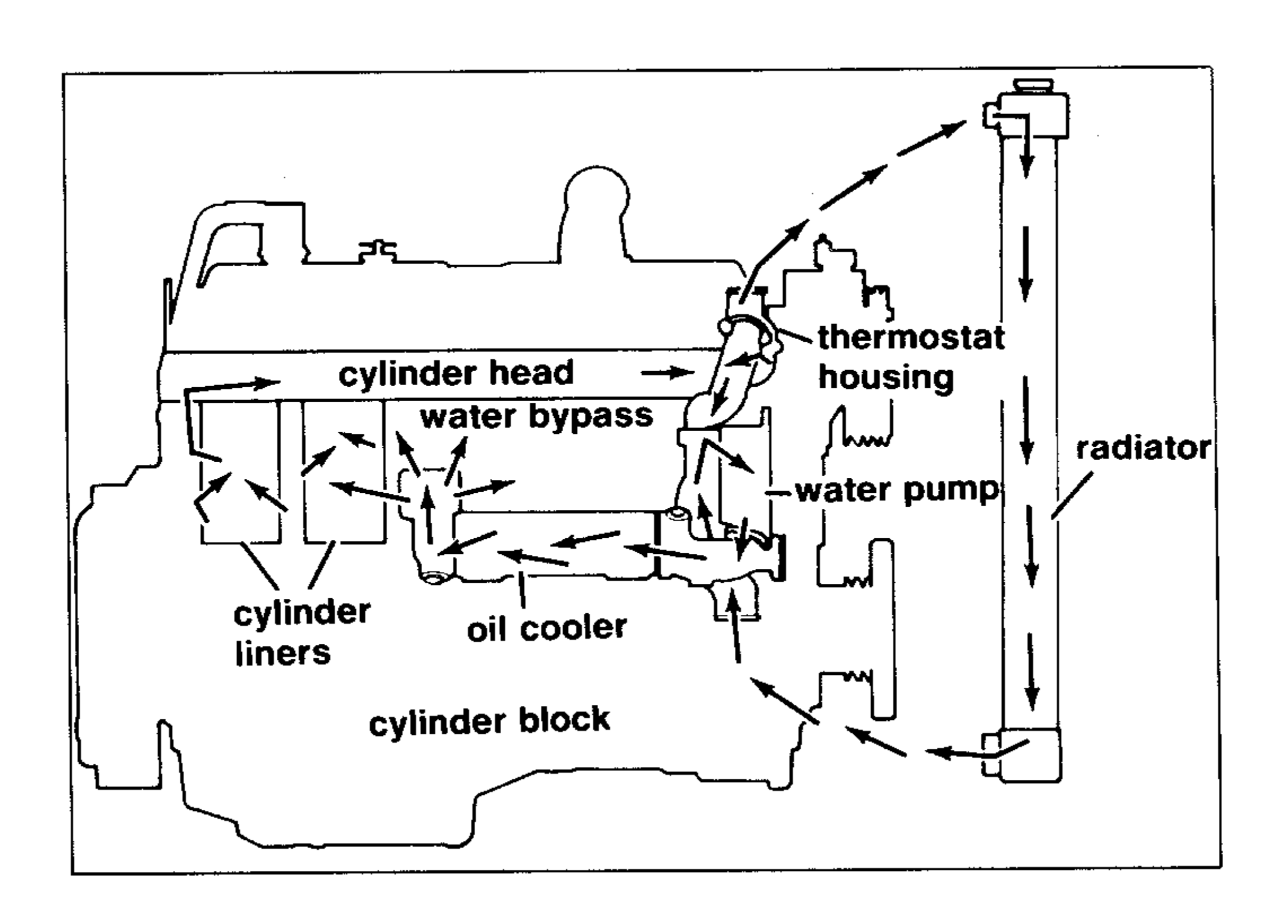
Basic components:

- radiator
- fan
- coolant
- water pump
- engine oil cooler
- water temperature regulator
- pressure cap


Keel Cooler


Shunt
Line





Coolant flow:

water pump

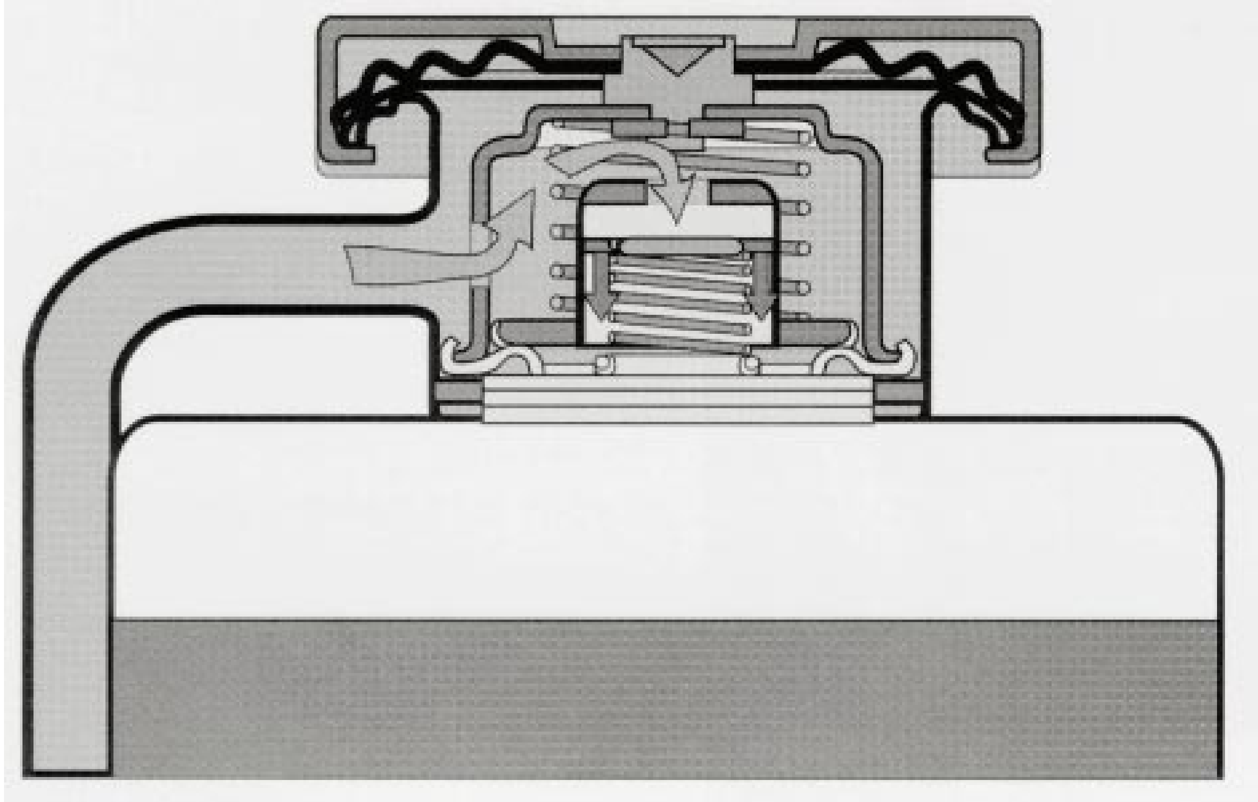
oil cooler

cylinder block

cylinder head

(radiator)

water pump



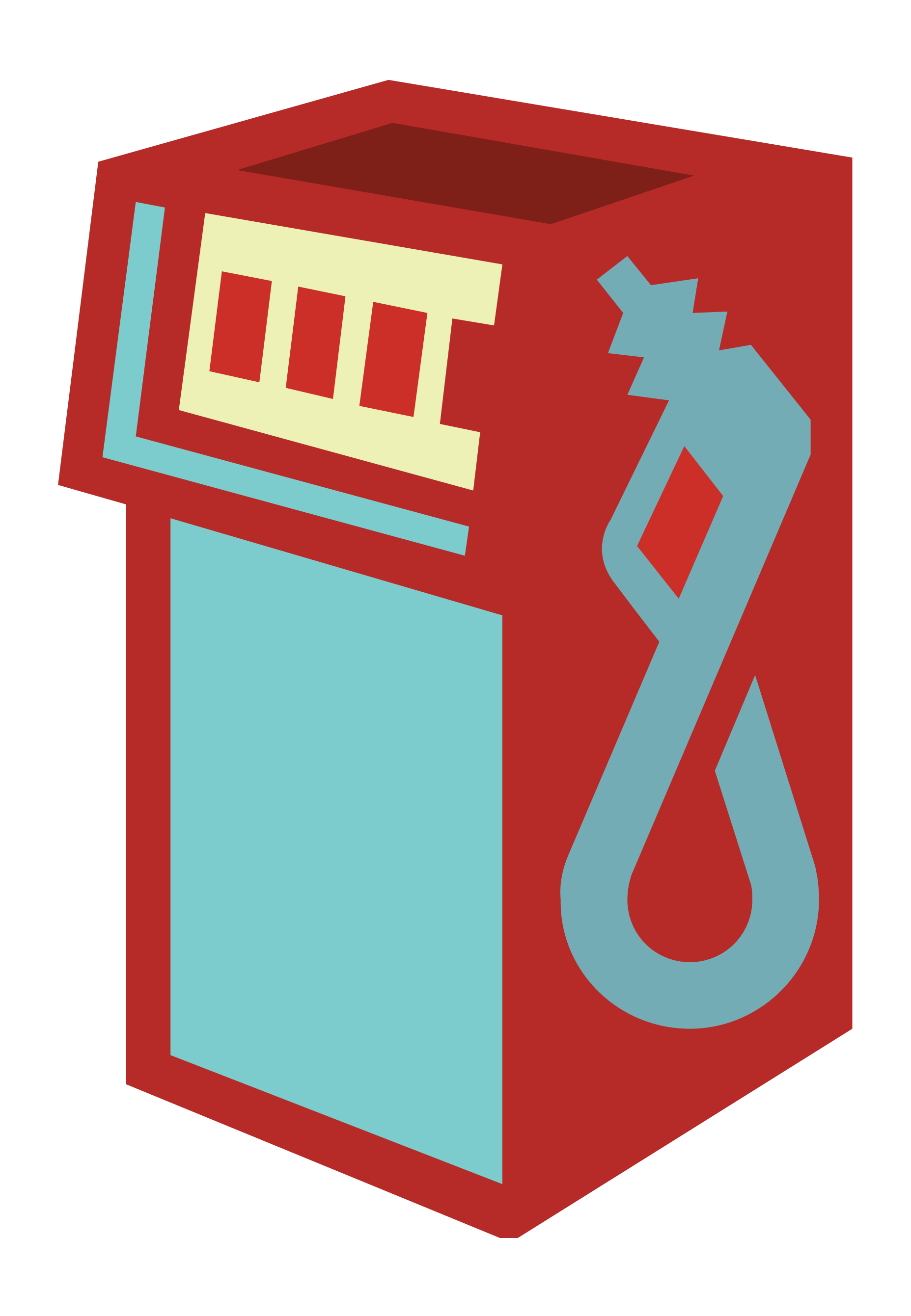
Altitude
feet meters
14,000 4 300
12,000 3 700
10,000 3 000
8,000 2 400
6,000 1 800
4,000 1 200
2,000 600
sea level 0

Cooling System Pressure
0 2 4 6 8 10 12 14 psi
0 14 25 40 55 70 85 95 kPa

180 190 200 210 220 230 240 250 °F
82 88 93 99 104 110 115 121 °C

Boiling Point of Water

Fuel system



Pump & lines

- Multiple plunger pump
- High pressure fuel lines
- Injection nozzles

- Limited injection pressure (18.000 PSI)*
- Limited injection timing
- Limited injection rate capabilities

MUI

- Mainly used on large engines to eliminate the need for long high pressure lines and the related problems inherent with controlling pressure in these lines.
- Requires an additional cam lobe, lifter, push rod and rocker arm for each cylinder.

*Current engine emissions and performance requirements demand injection pressure in excess of 20.000 PSI and greater timing flexibility.

PEEC (Programmable **E**lectronic **E**ngine **C**ontrol)

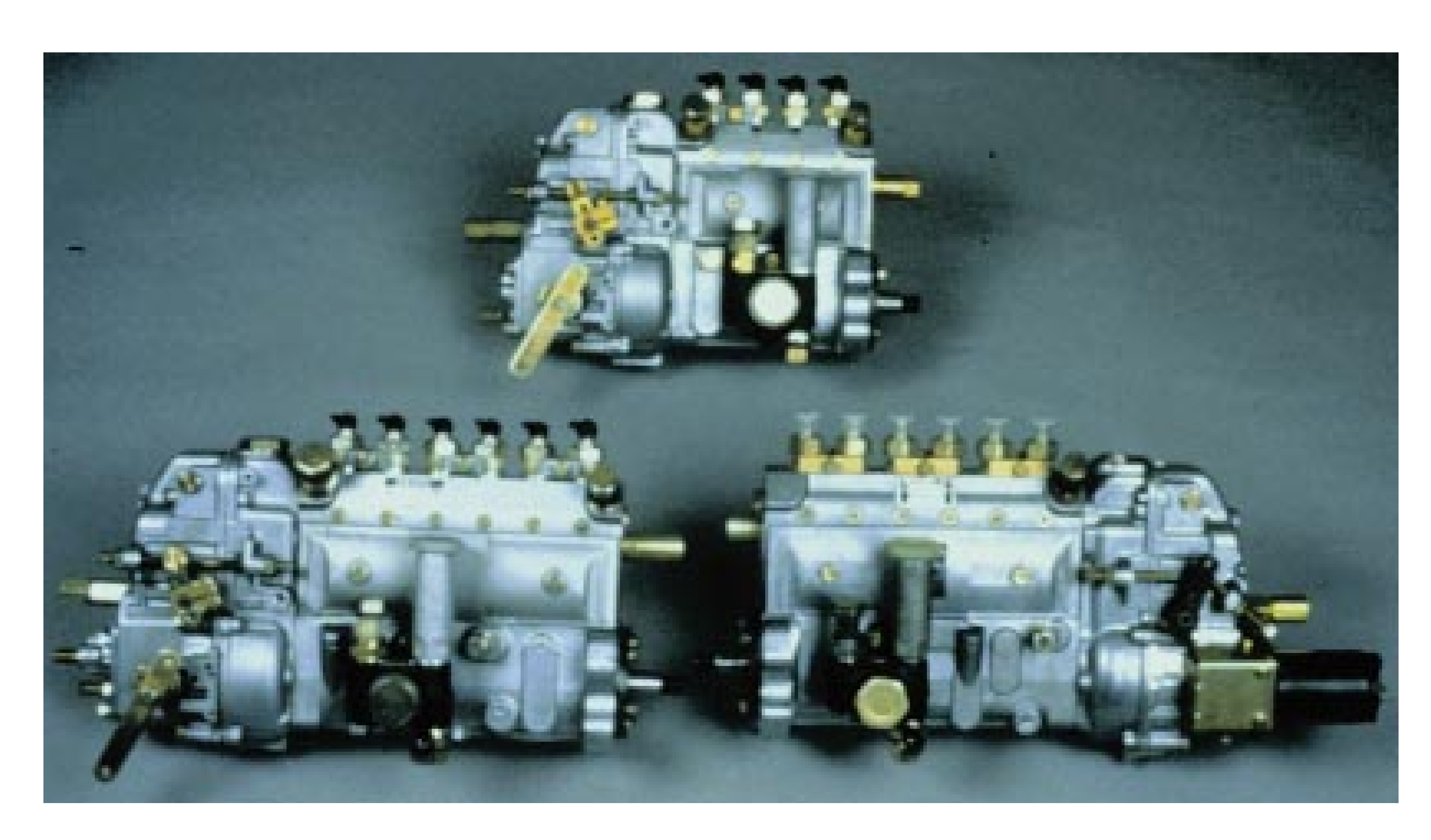
- **ECM** takes over of the functions of the mechanical governor.
- Fuel pump is still used.
- Throttle linkage replaced by electronic throttle.
- Air fuel ratio control electronically controlled.
- Engine is equipped with various sensors for monitoring.

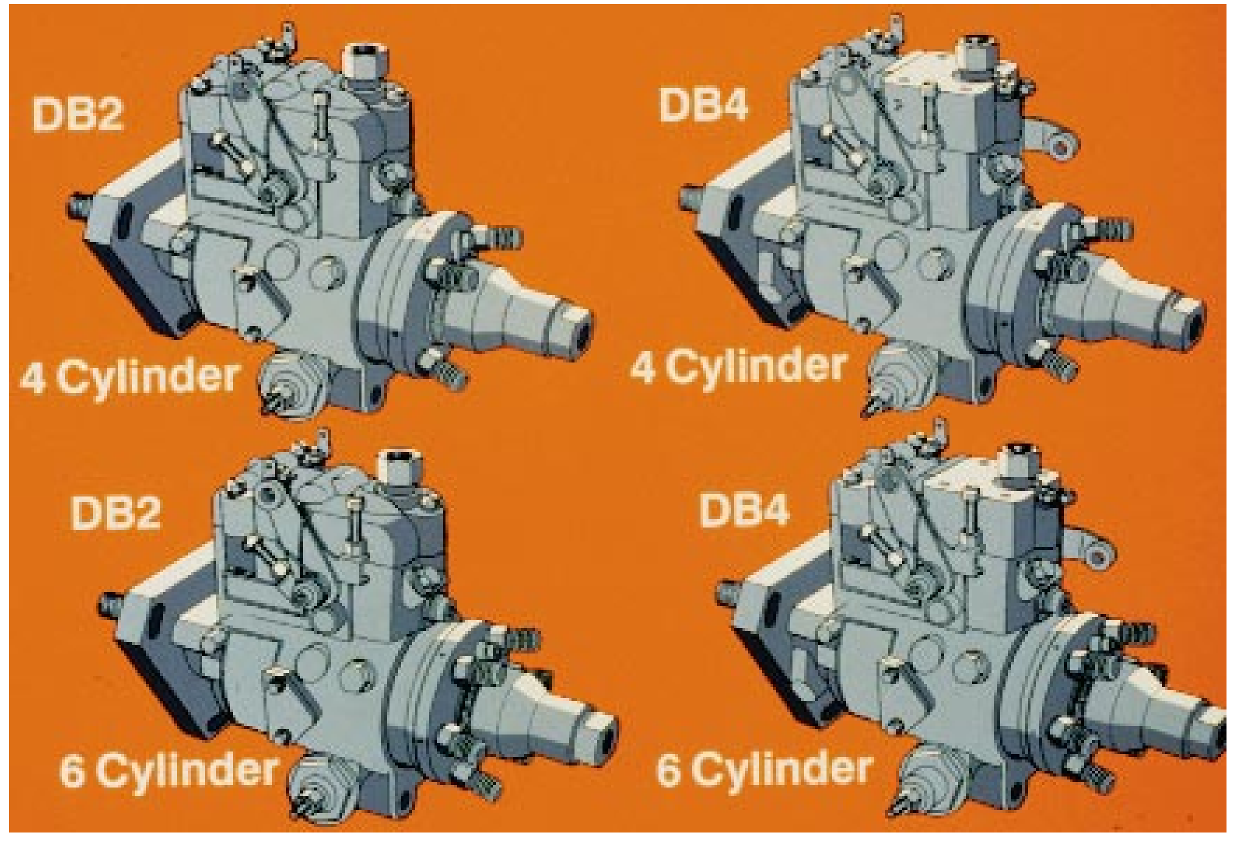
EUI / MEUI (**M**echanical **E**lectronic **U**nit **I**njectors)

- Fuel is metered electronically by means of a solenoid operated poppet valve.
- System still requires a mechanical valve train to actuate the plunger.
  (Mechanically actuated , electronically controlled)
- Fuel transfer pump replaces the "pump & lines".

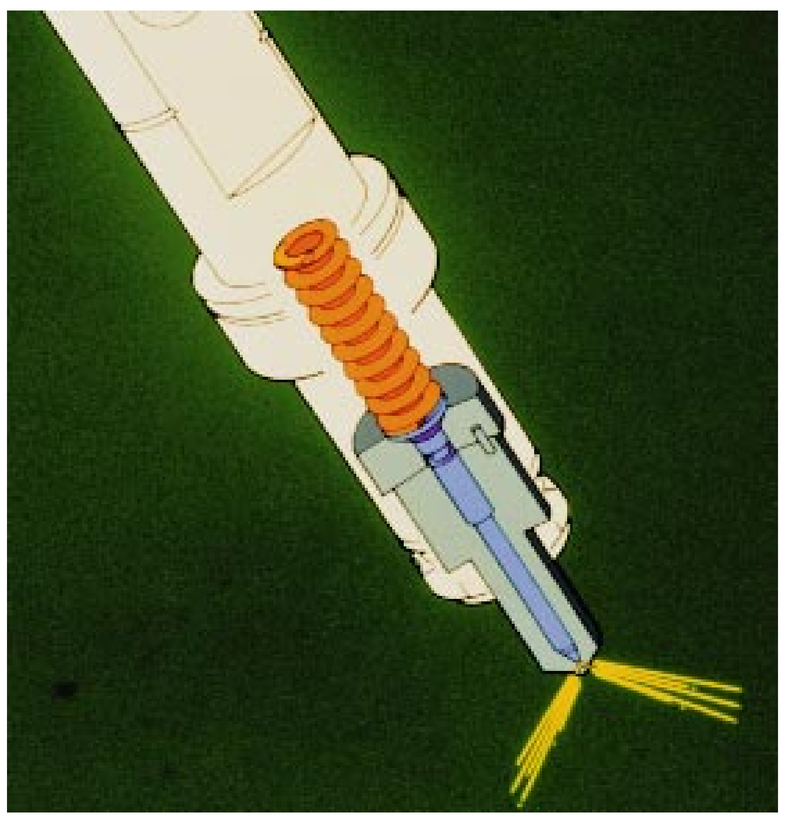
HEUI (Hydraulic Electronic **U**nit **I**njectors)

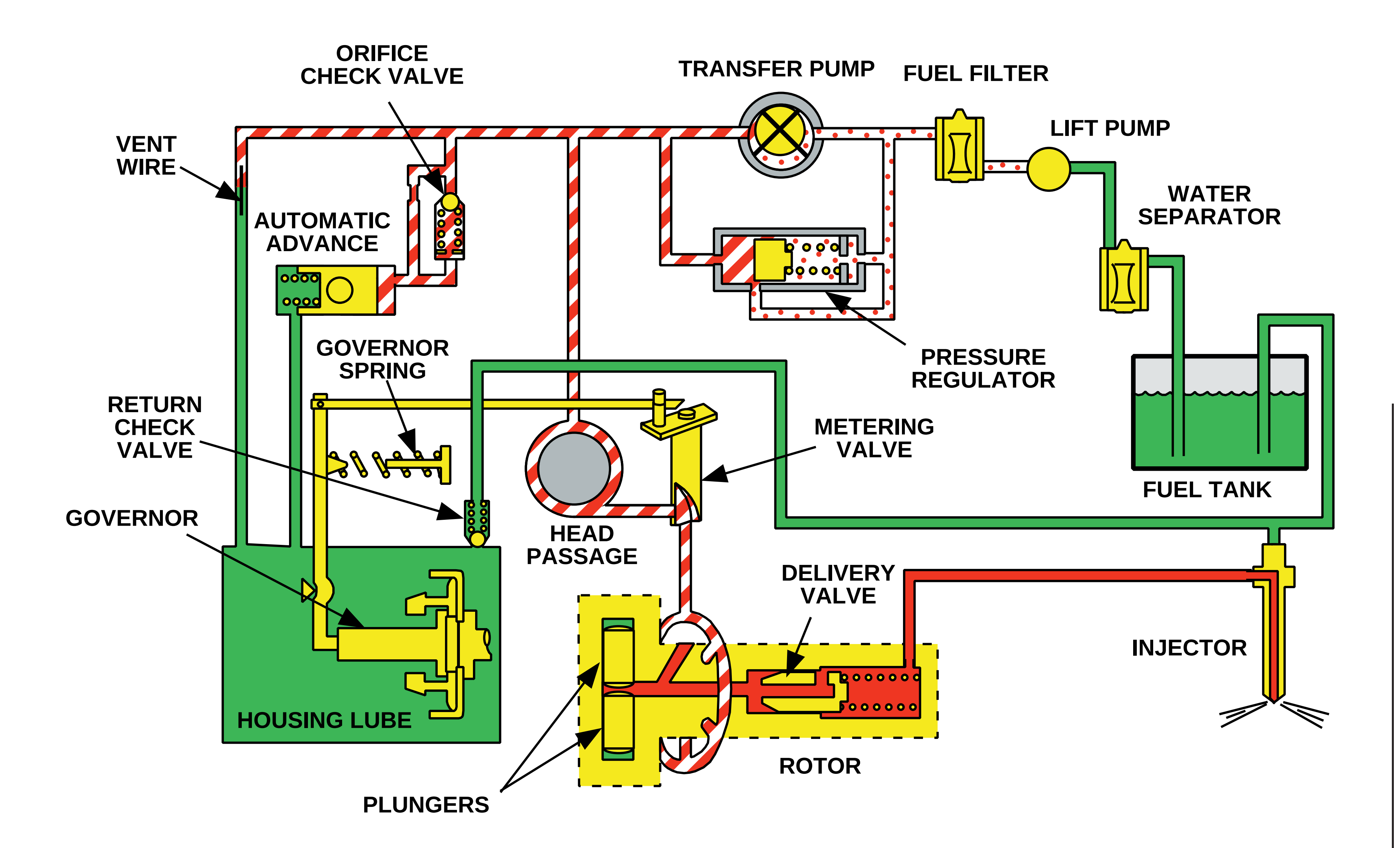
- Plunger movement is not limited to speed or duration of a cam lobe.
- Plunger speed is a function of actuation pressure versus fuel pumping resistance.
  (Hydraulically actuated , electronically controlled)
- Injection pressure is +20.000 PSI

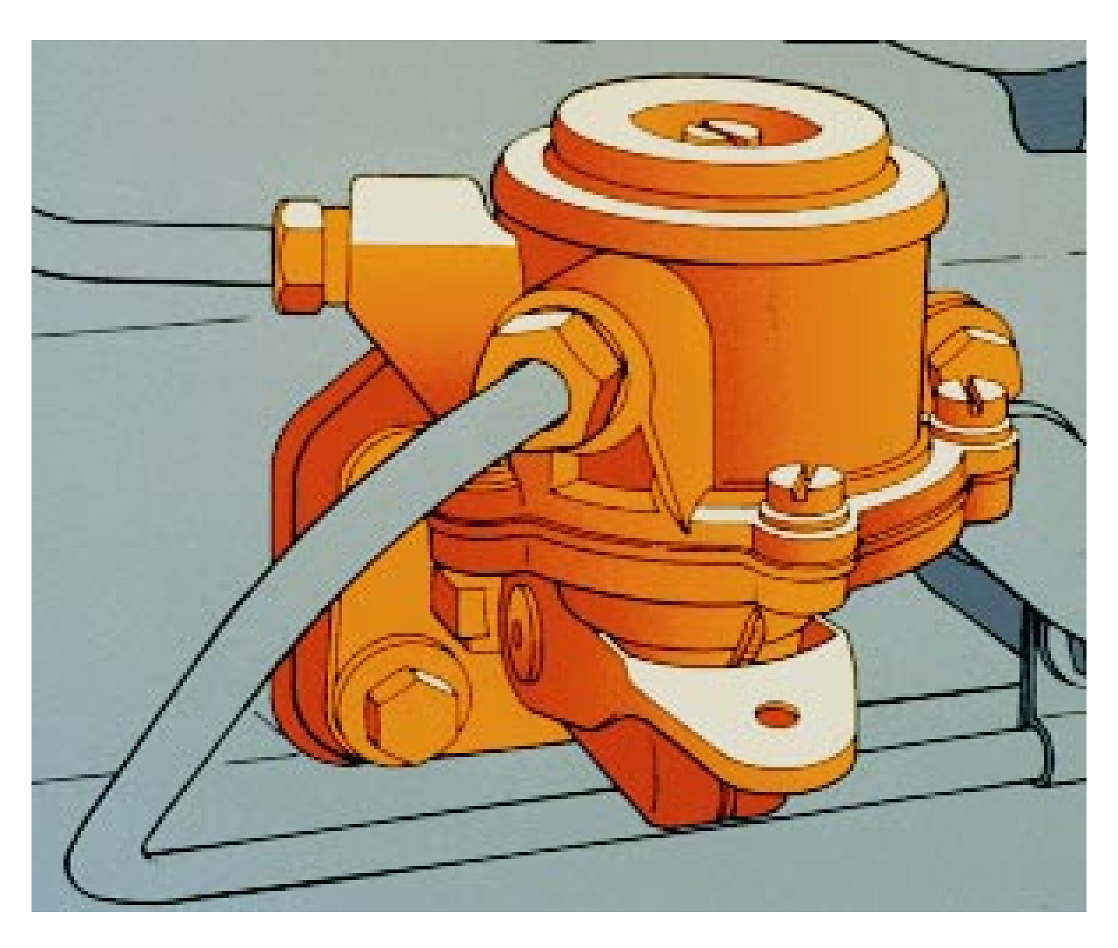


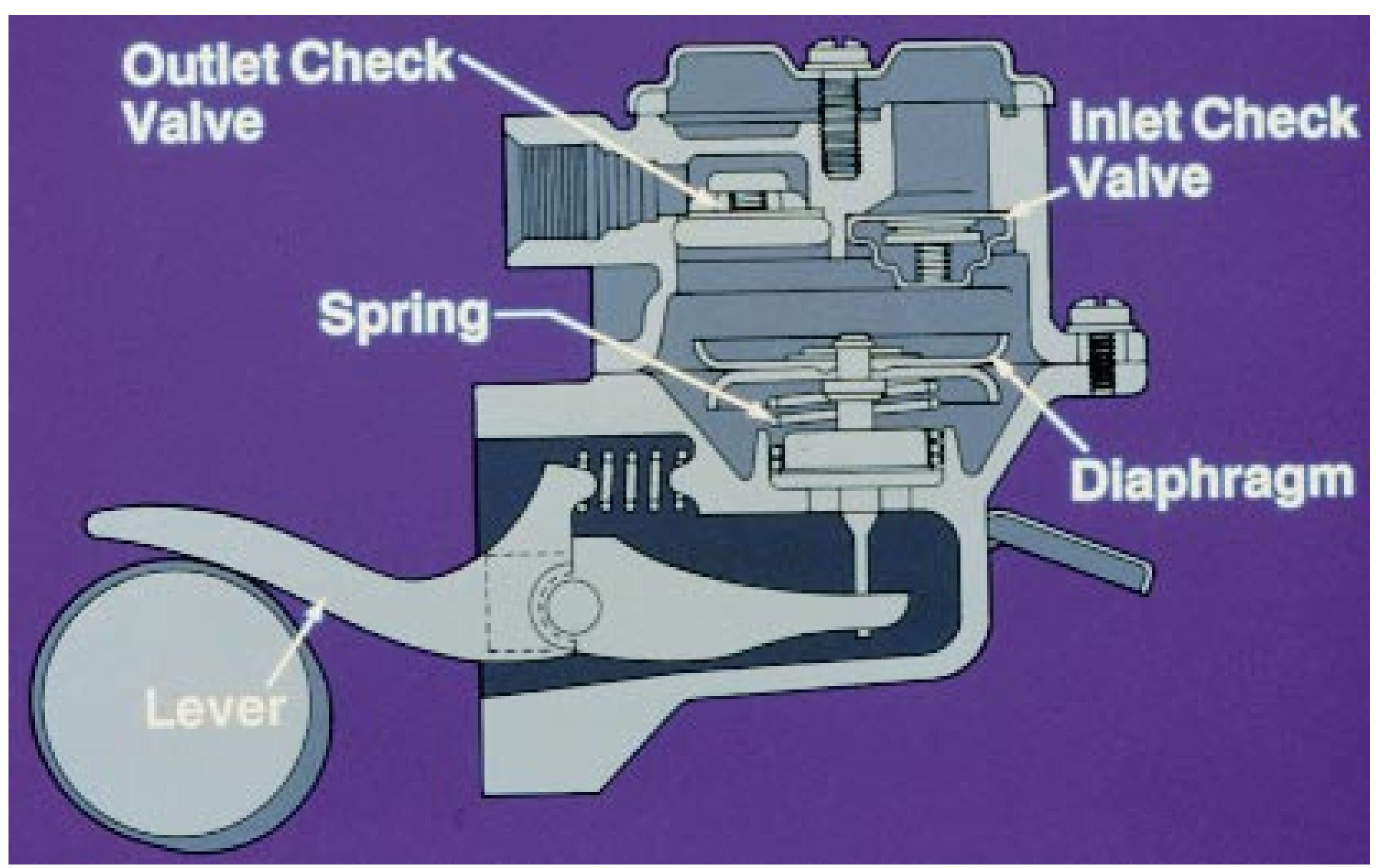

DB2
4 Cylinder
DB4
4 Cylinder
DB2
6 Cylinder
DB4
6 Cylinder

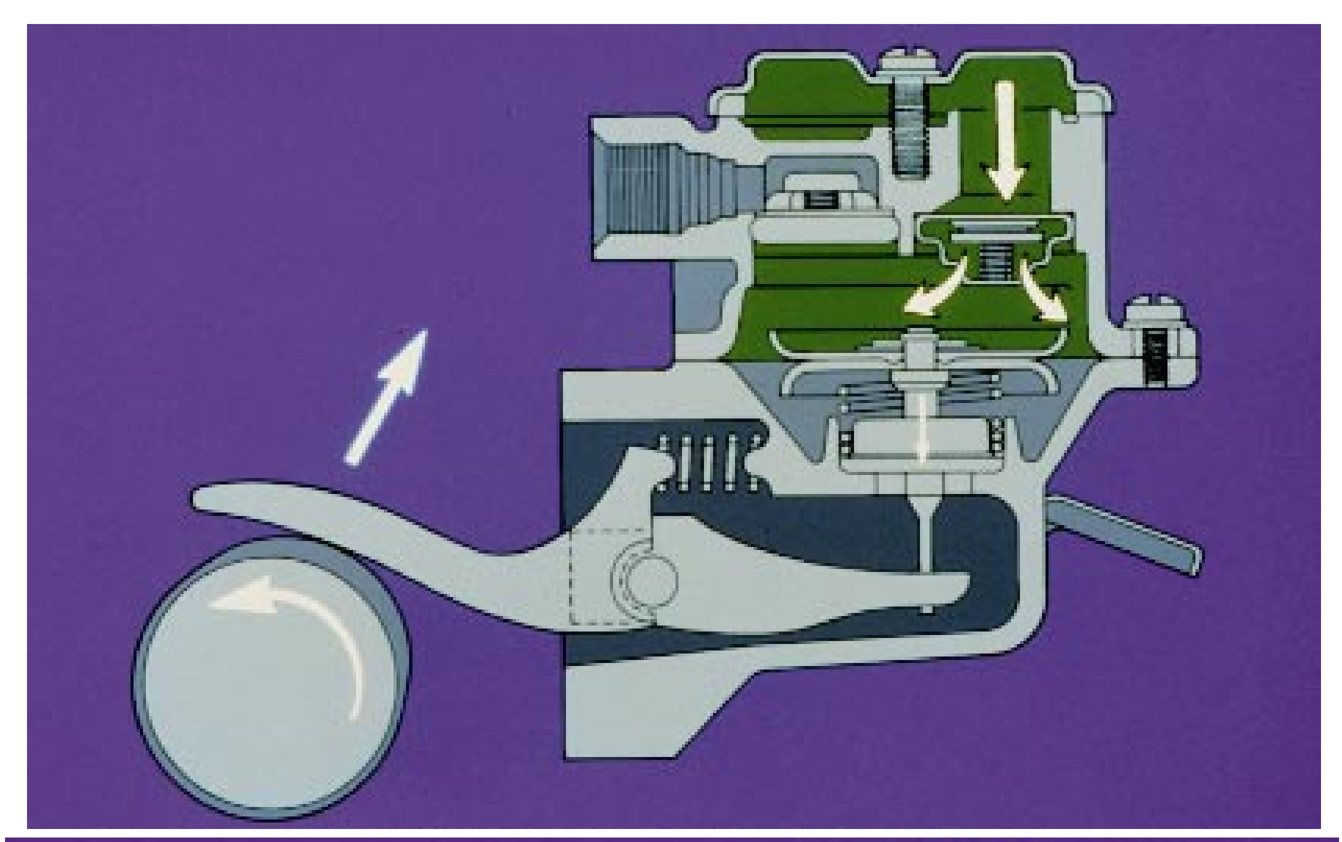
Fuel Filter
Fuel Drain Line
Fuel Pump
Transfer Pump
Injector
High Pressure Lines
Lift Pump
Low Pressure Lines
Fuel Filter




ORIFICE
CHECK VALVE
TRANSFER PUMP
FUEL FILTER
LIFT PUMP
VENT
WIRE
AUTOMATIC
ADVANCE
WATER
SEPARATOR
PRESSURE
REGULATOR
GOVERNOR
SPRING
RETURN
CHECK
VALVE
METERING
VALVE
FUEL TANK
GOVERNOR
HEAD
PASSAGE
DELIVERY
VALVE
INJECTOR
HOUSING LUBE
ROTOR
PLUNGERS




Outlet Check
Valve
Inlet Check
Valve
Spring
Diaphragm
Lever



FUEL RETURN CHECK VALVE

CAM

GOVERNOR SPRING

METERING VALVE

FUEL OUTLET

ROLLER

PRESSURE REGULATOR

PISTON

GOVERNOR WEIGHTS

TRANSFER PUMP

SHOE

ROTOR

DELIVERY VALVE

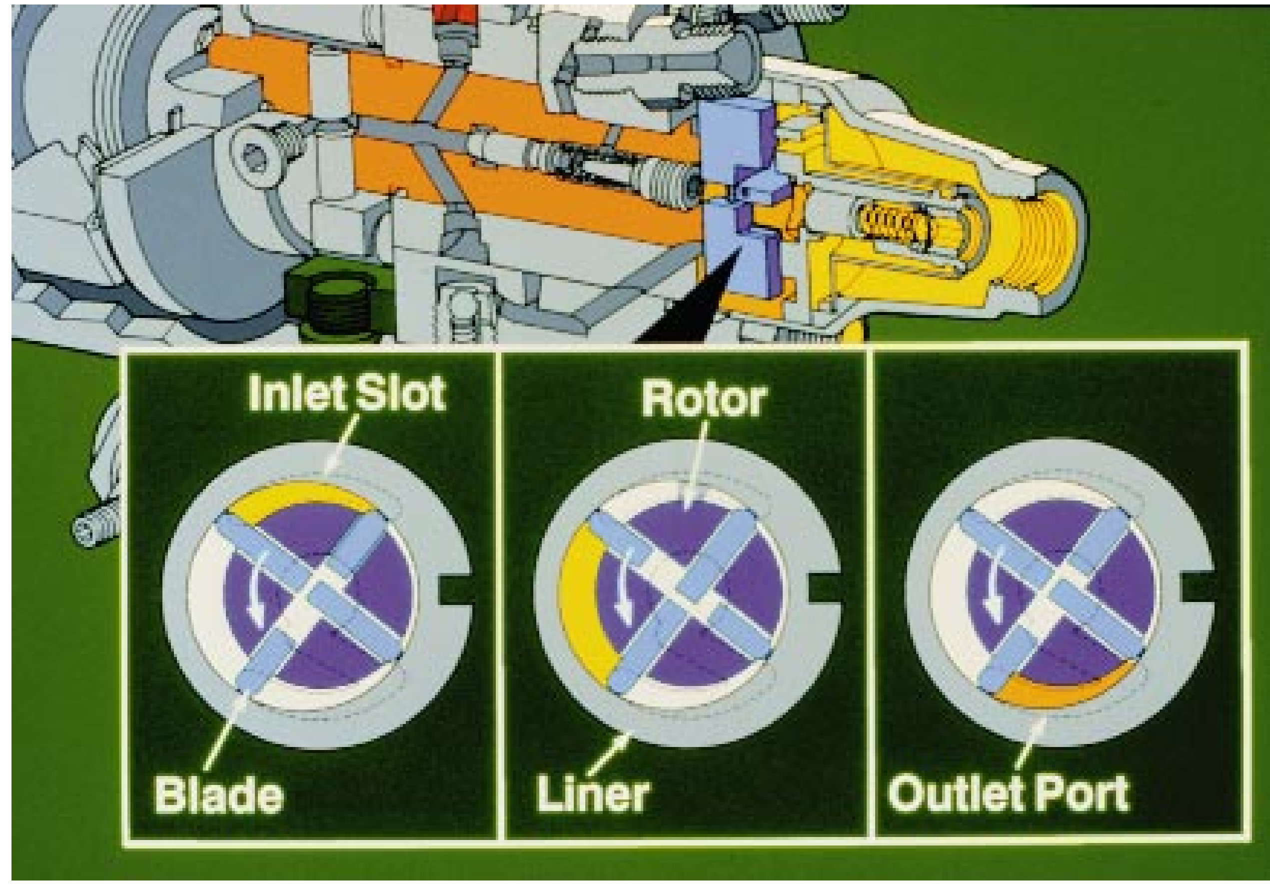
AUTOMATIC ADVANCE MECHANISM

ORIFICE CHECK VALVE



Blades

Pump Shaft



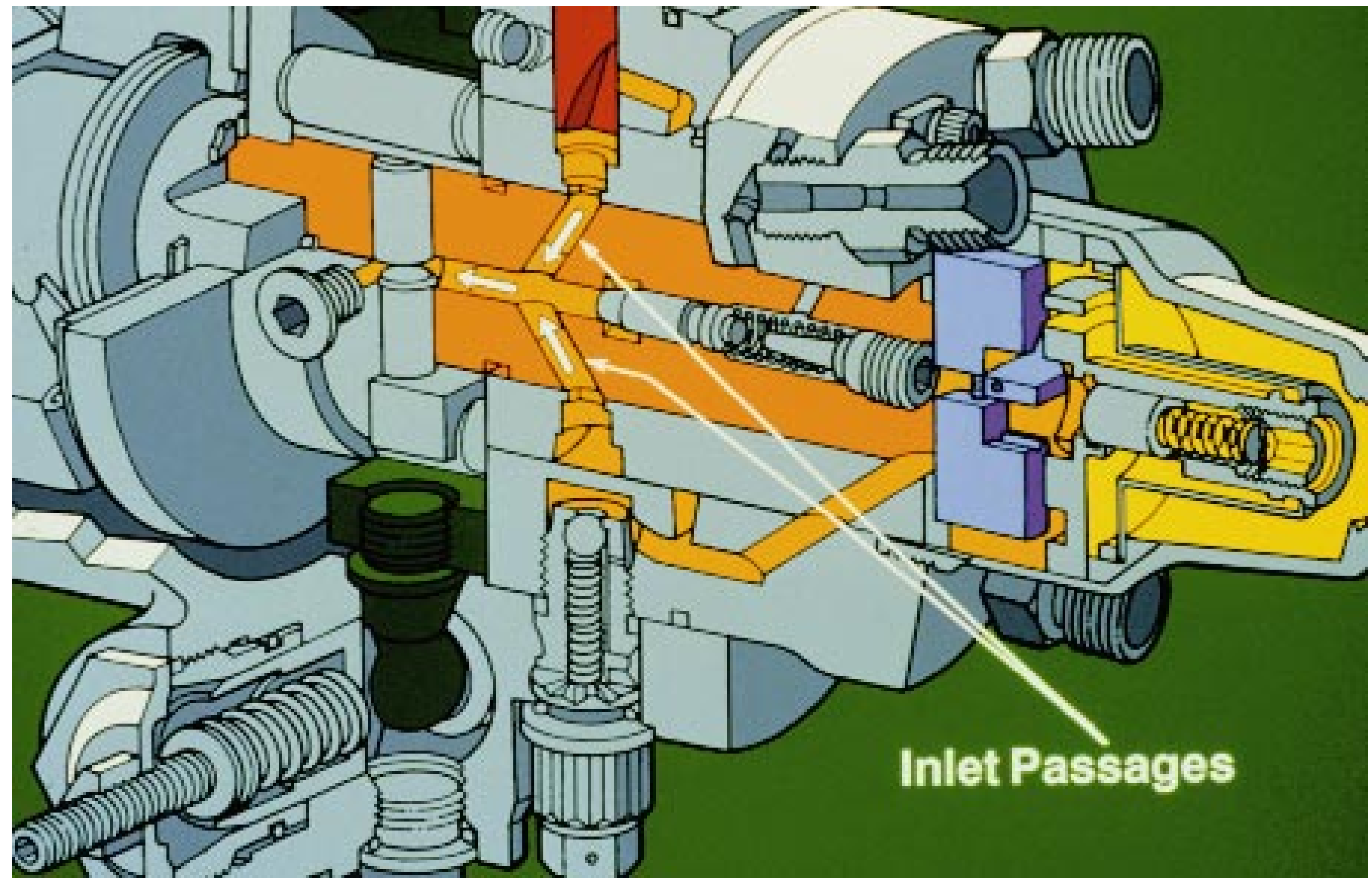
Metering Valve

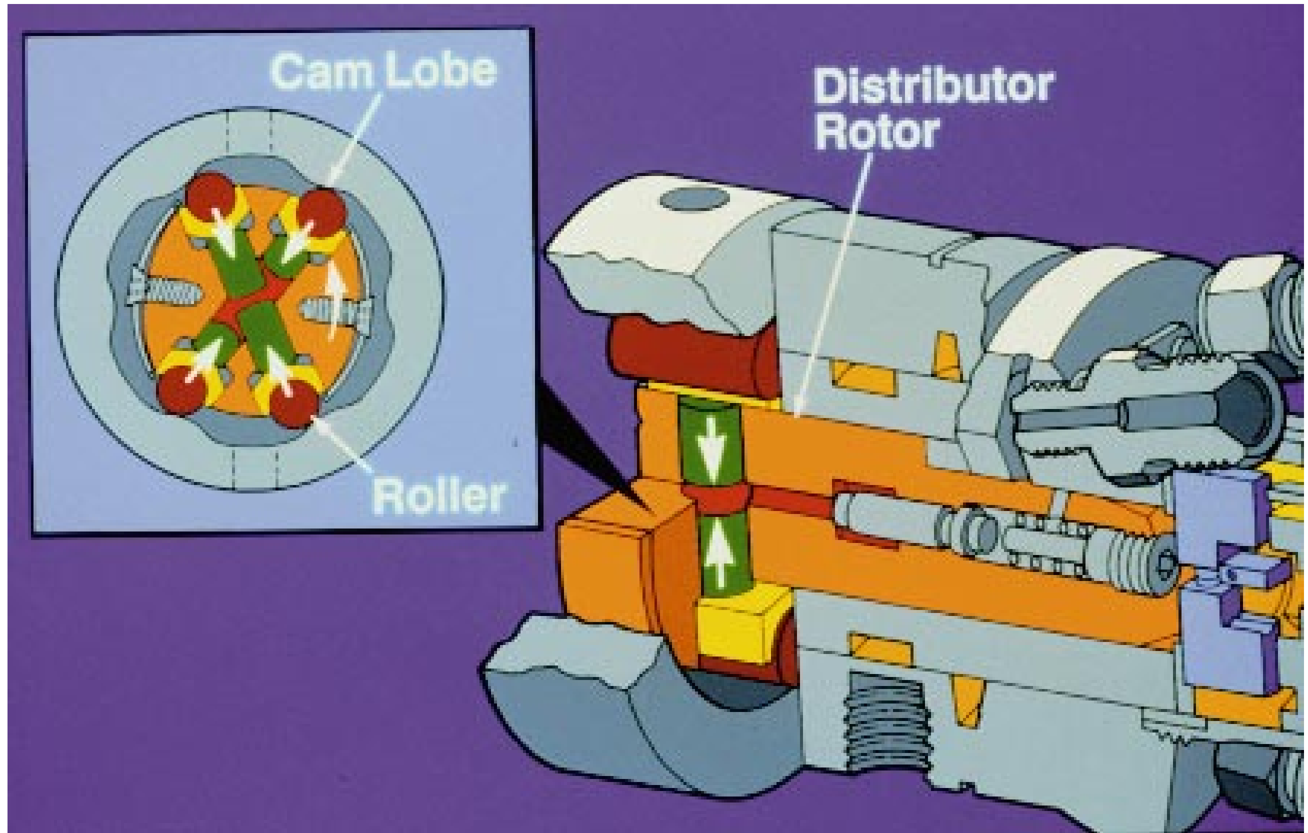
Check Valve



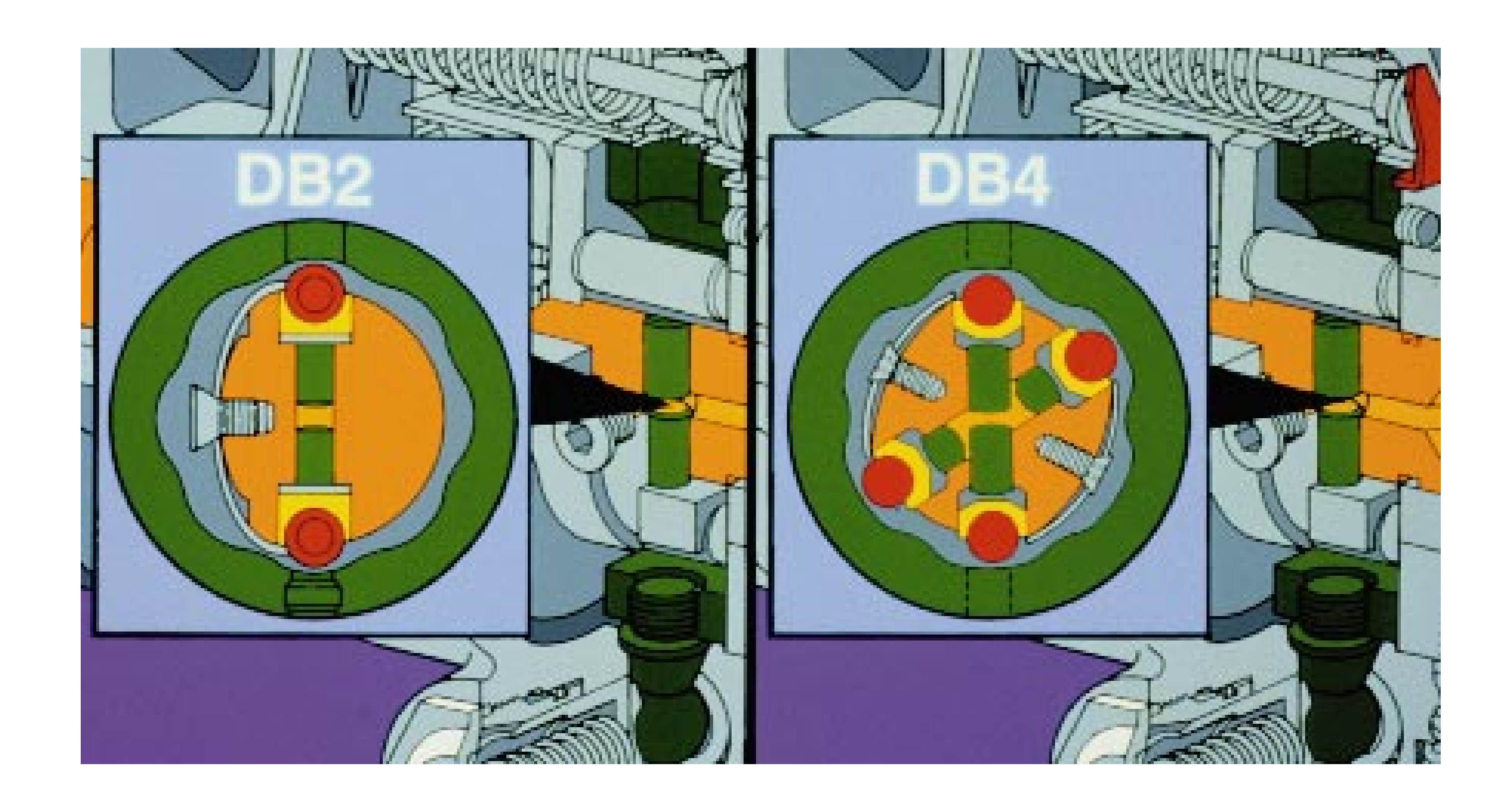
Charging Passages

Radial Charging Passage




Cam Lobe
Distributor
Rotor
Roller





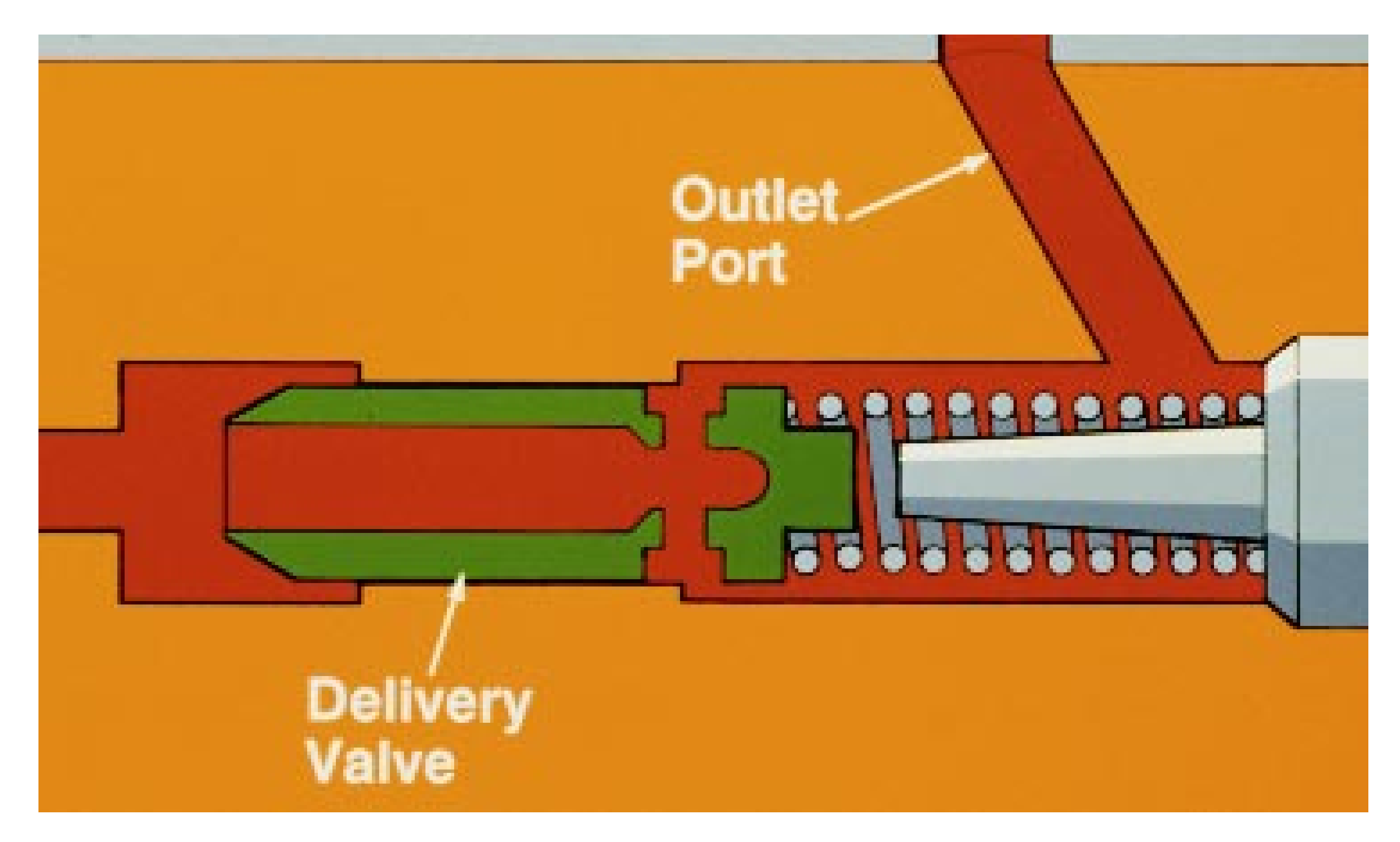
Contact

Start of Injection

Discharge Port
Inlet Port
Outlet Port


CATERPILLAR®

Outlet
Port
Delivery Valve


Outlet
Port
Delivery
Valve


CATERPILLAR®

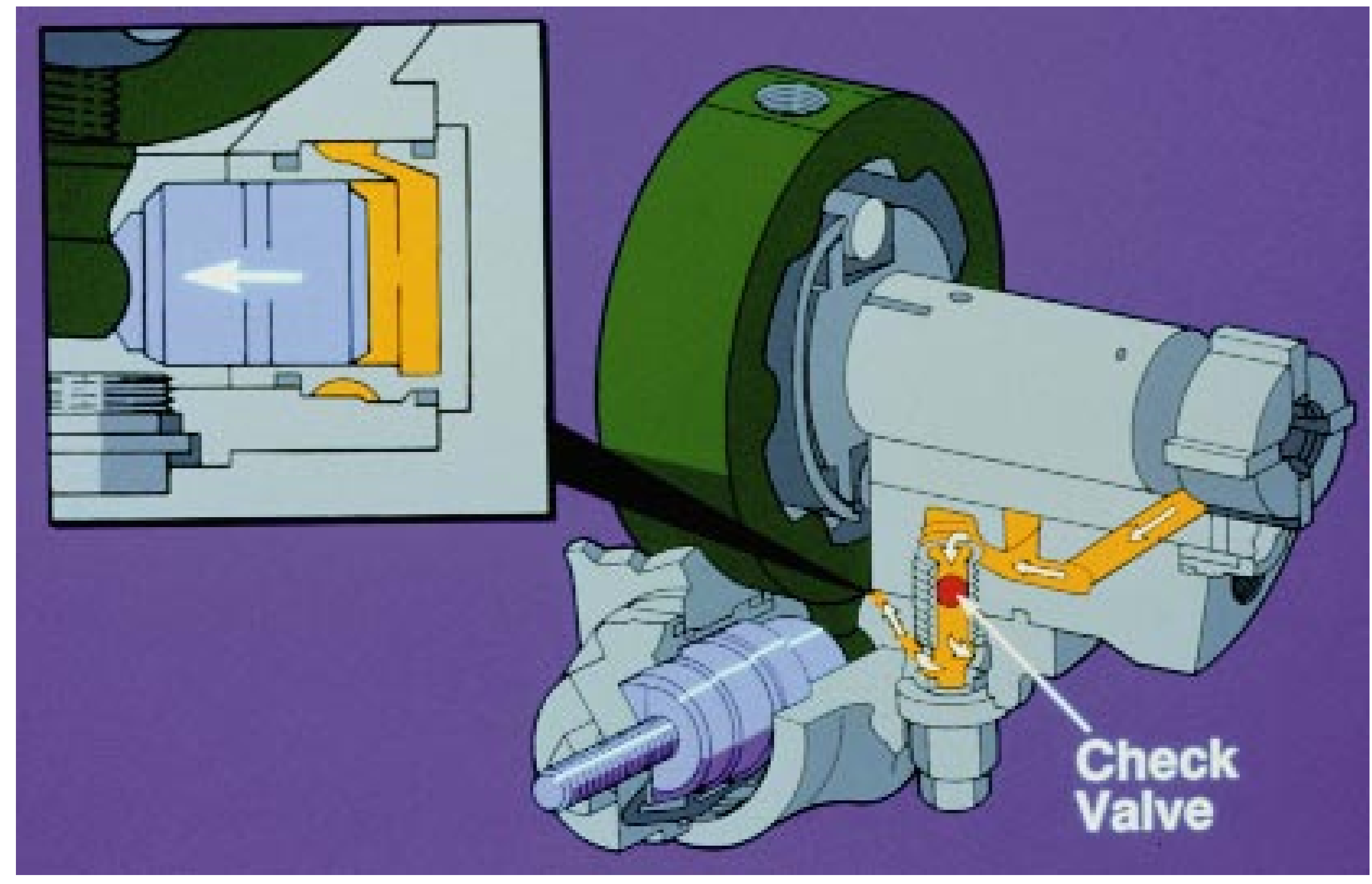
Outlet
Port
Discharge
Ports

Cam Ring

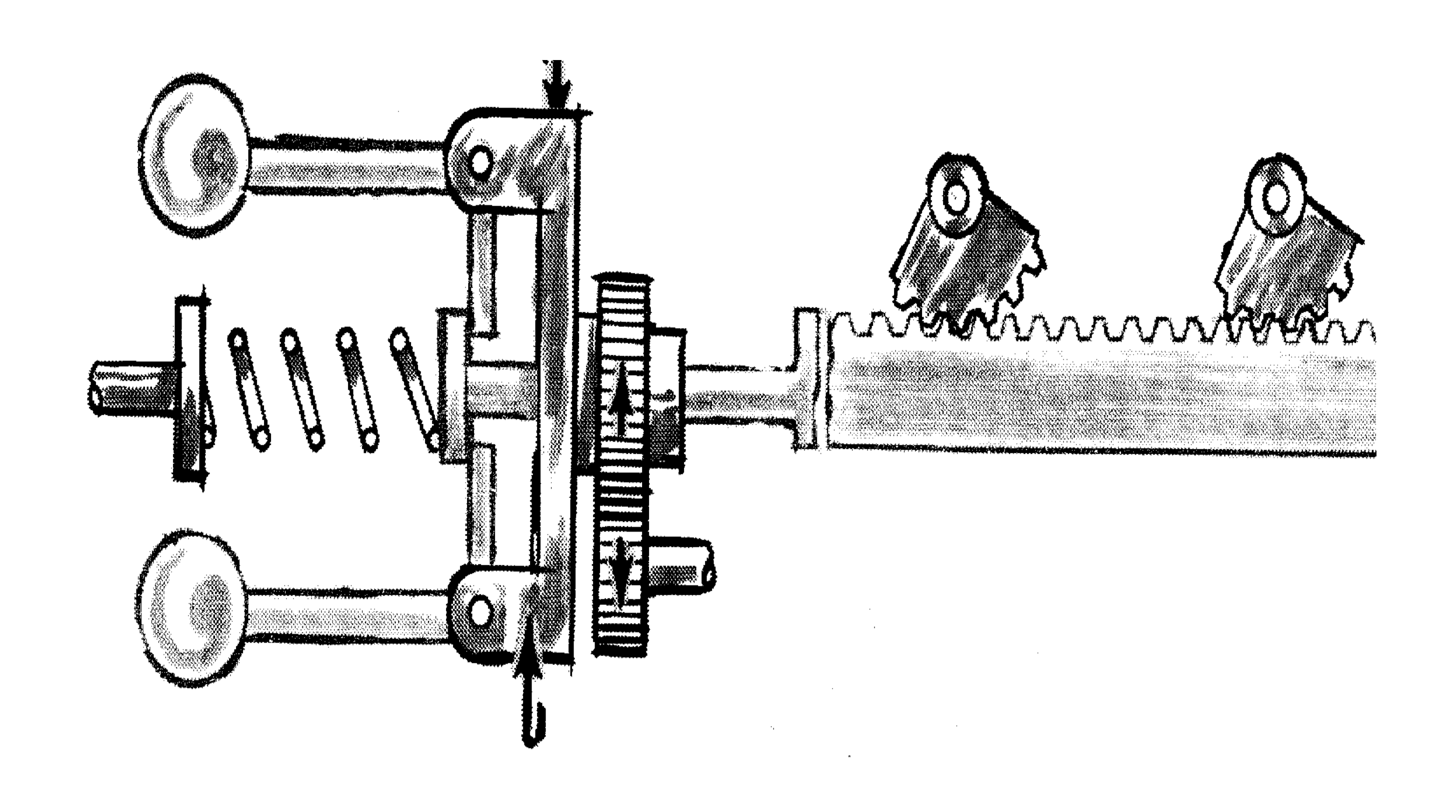
Spring Side Piston

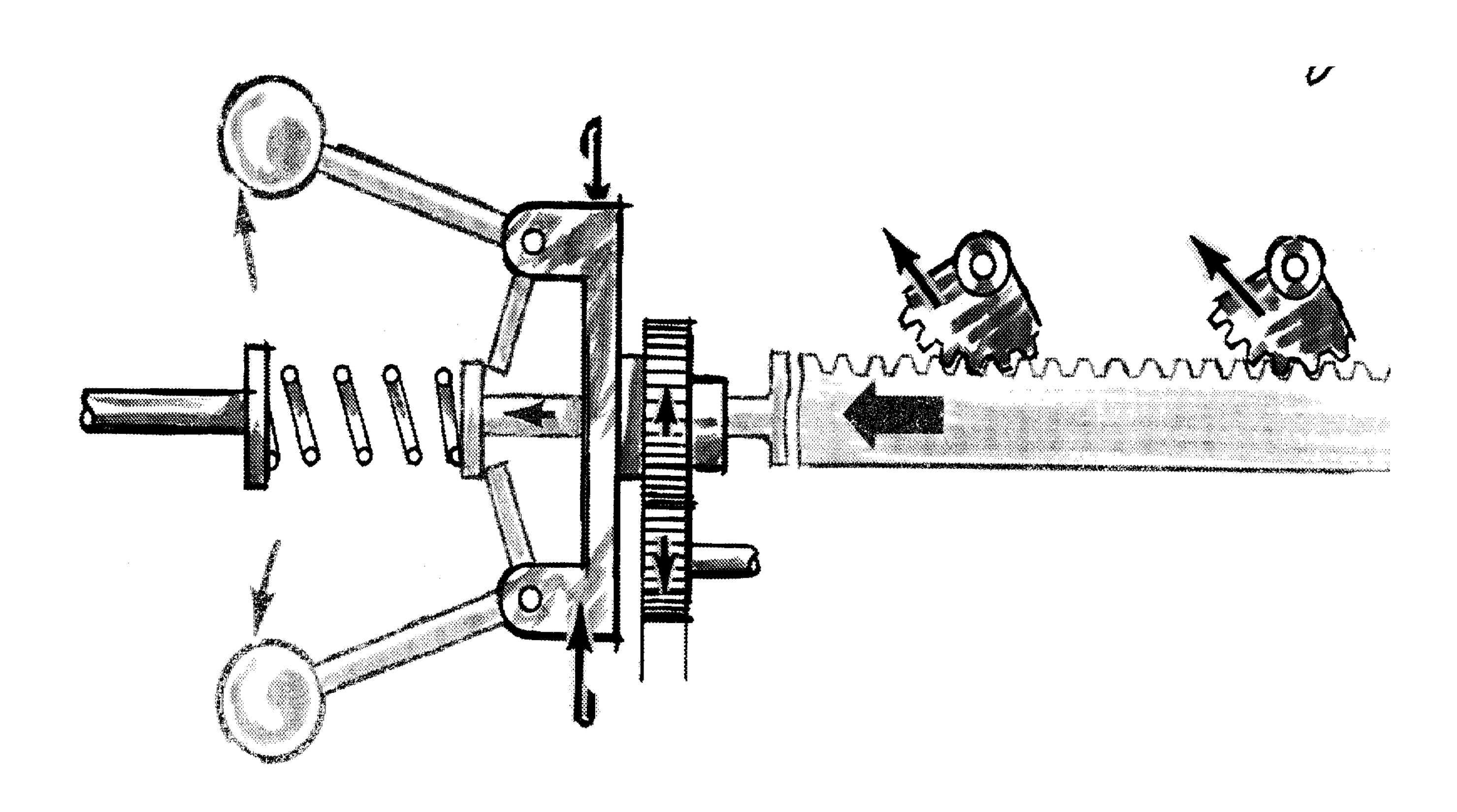
Spring

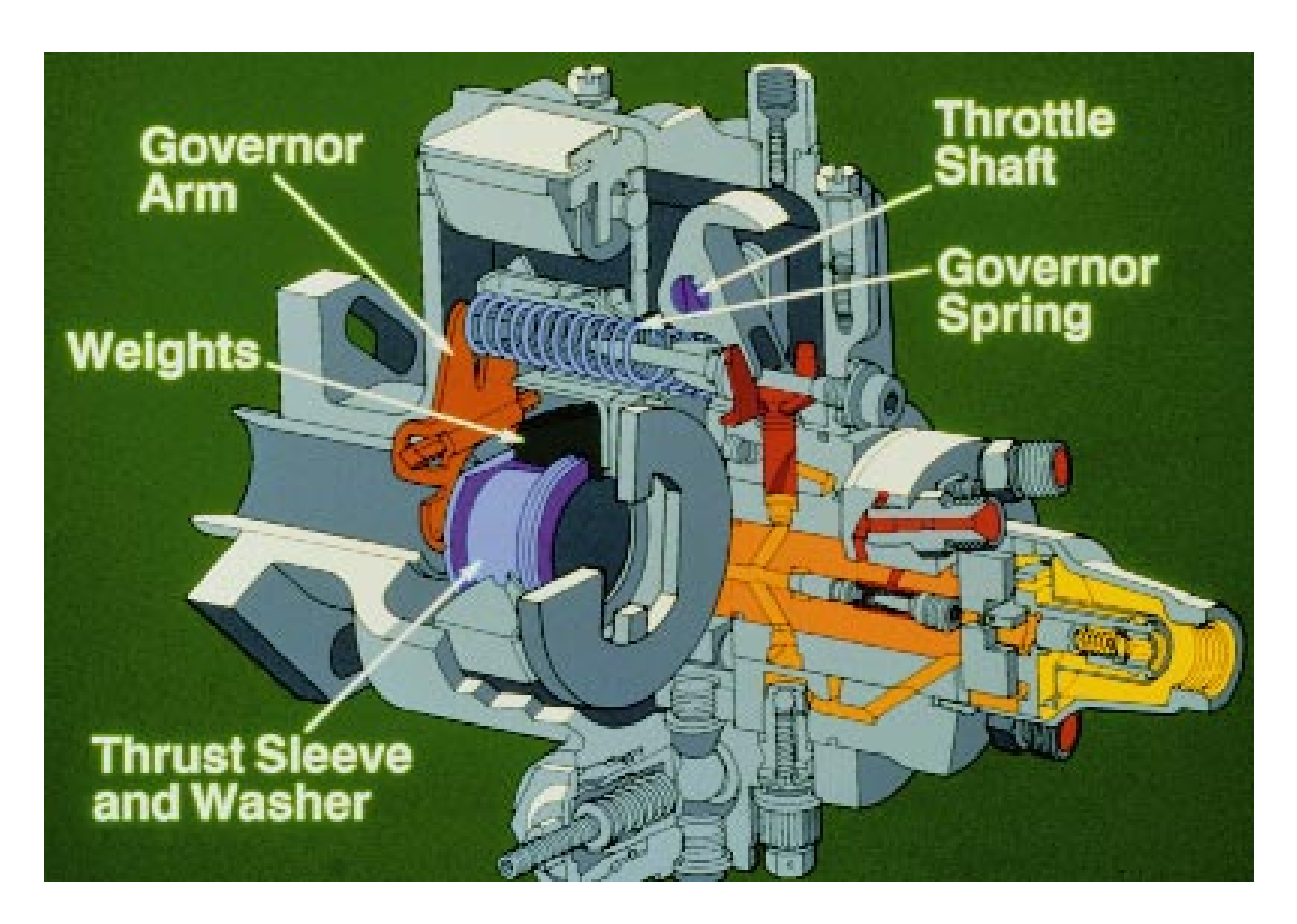
Power Piston



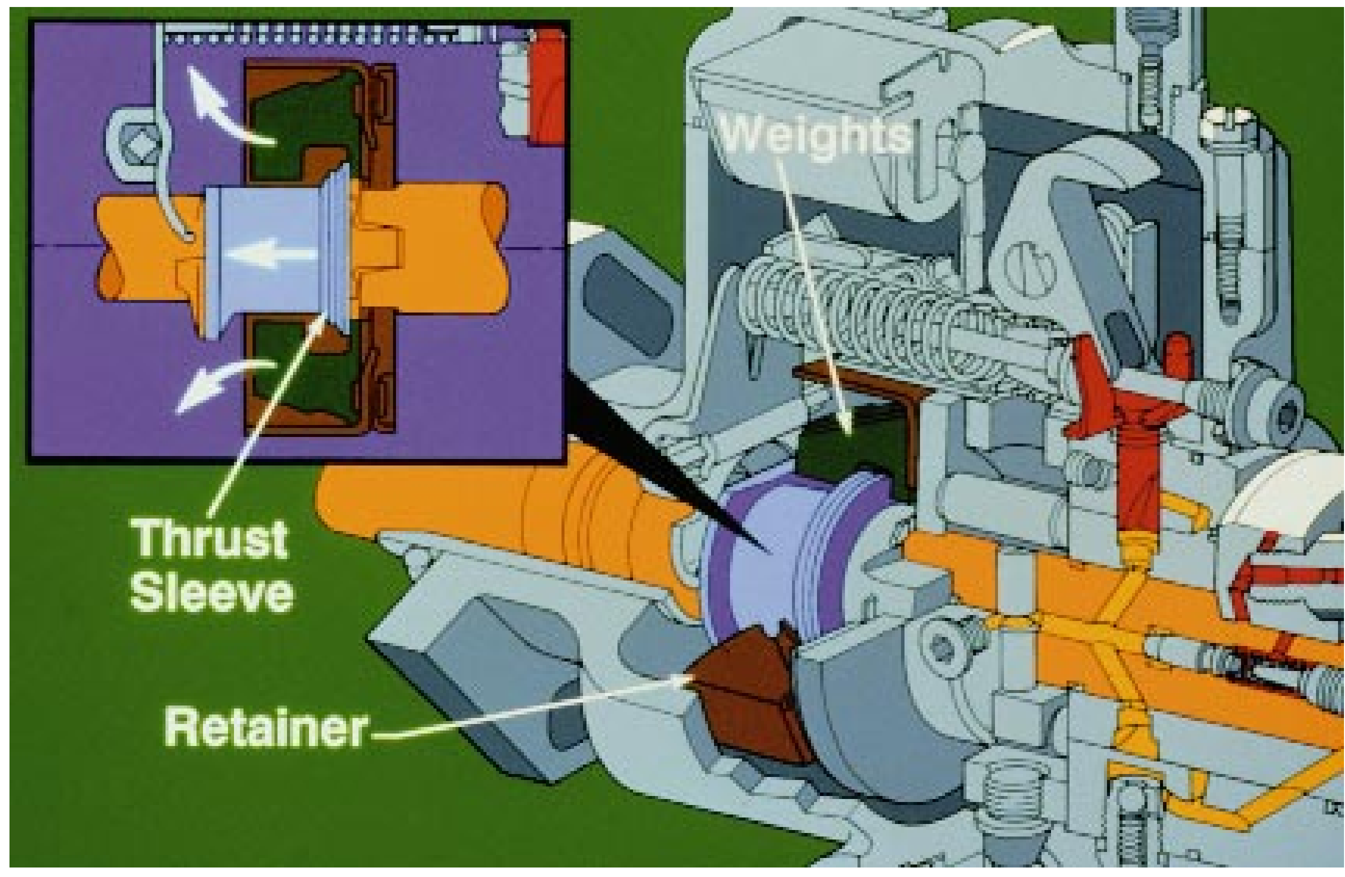




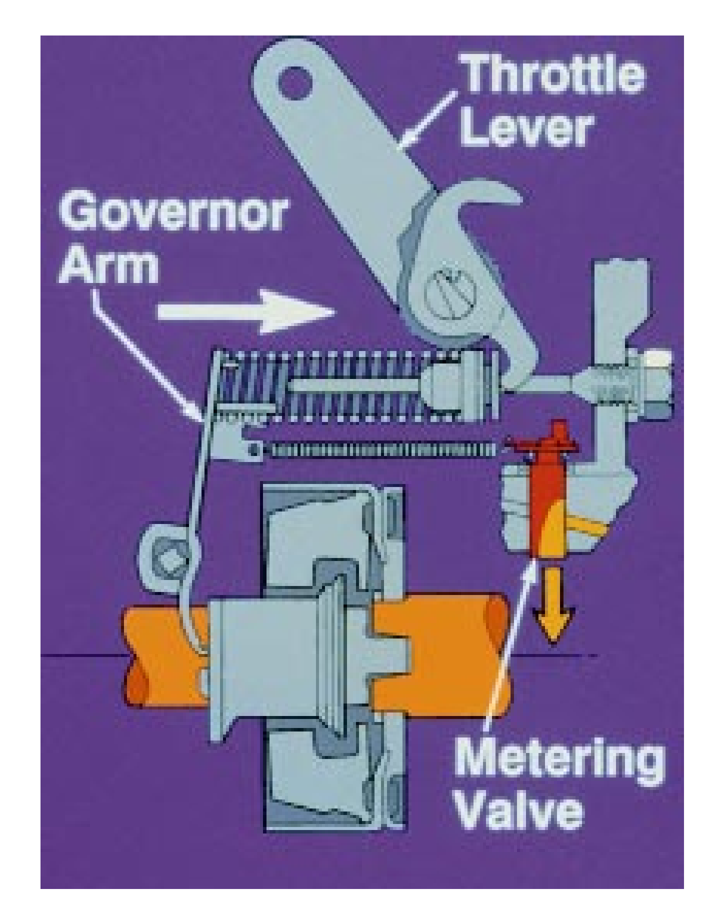


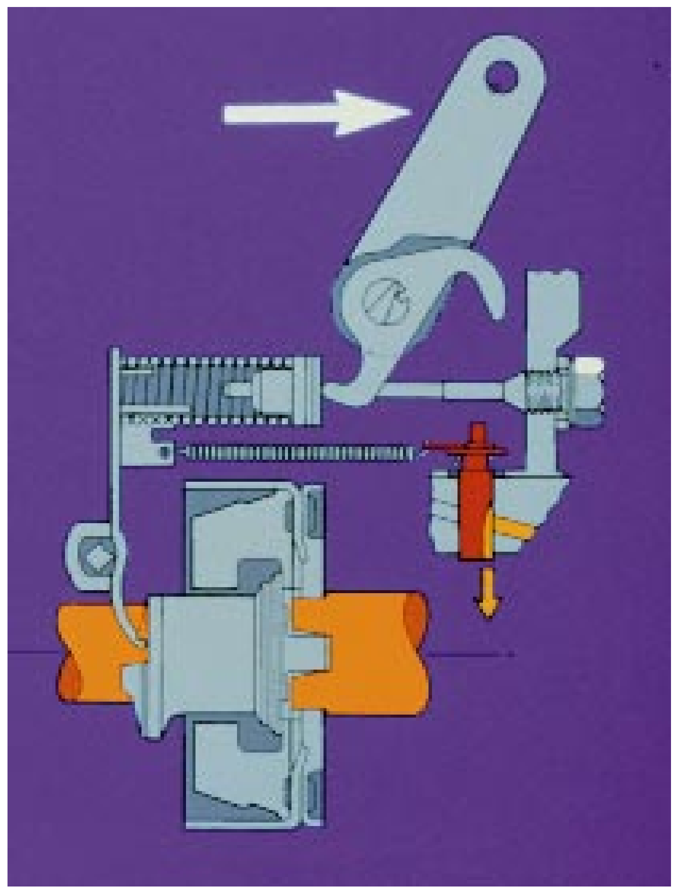


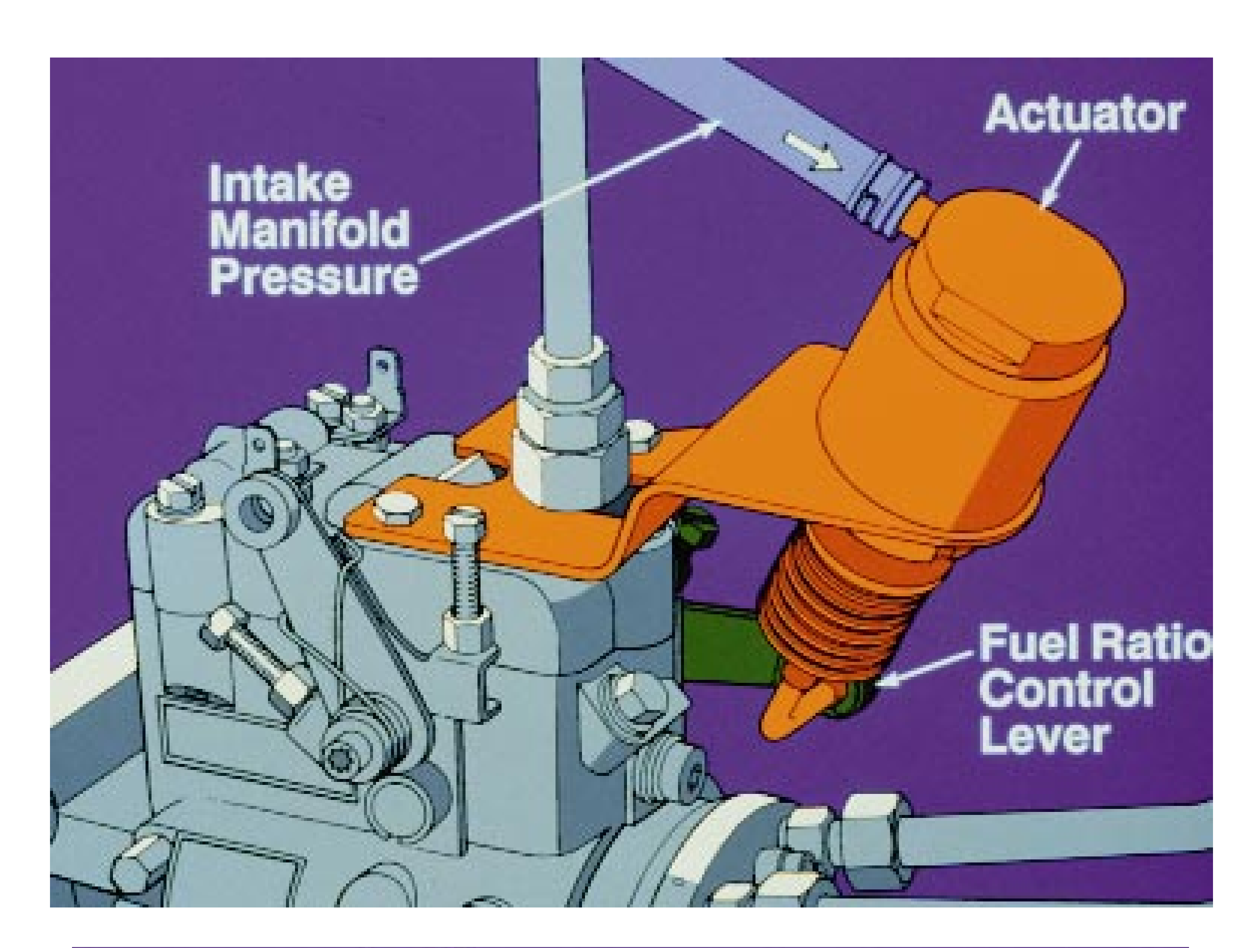
Governor Arm
Throttle Shaft
Governor Spring
Weights
Thrust Sleeve and Washer

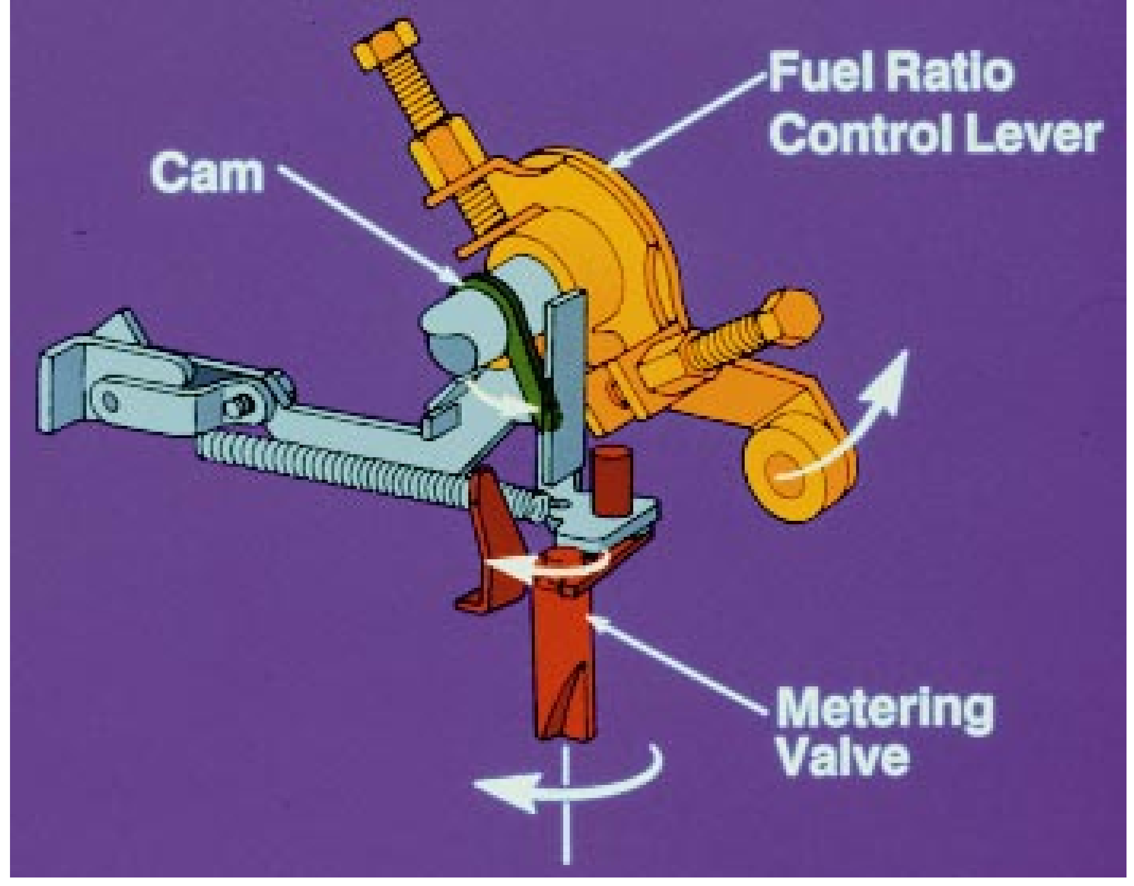


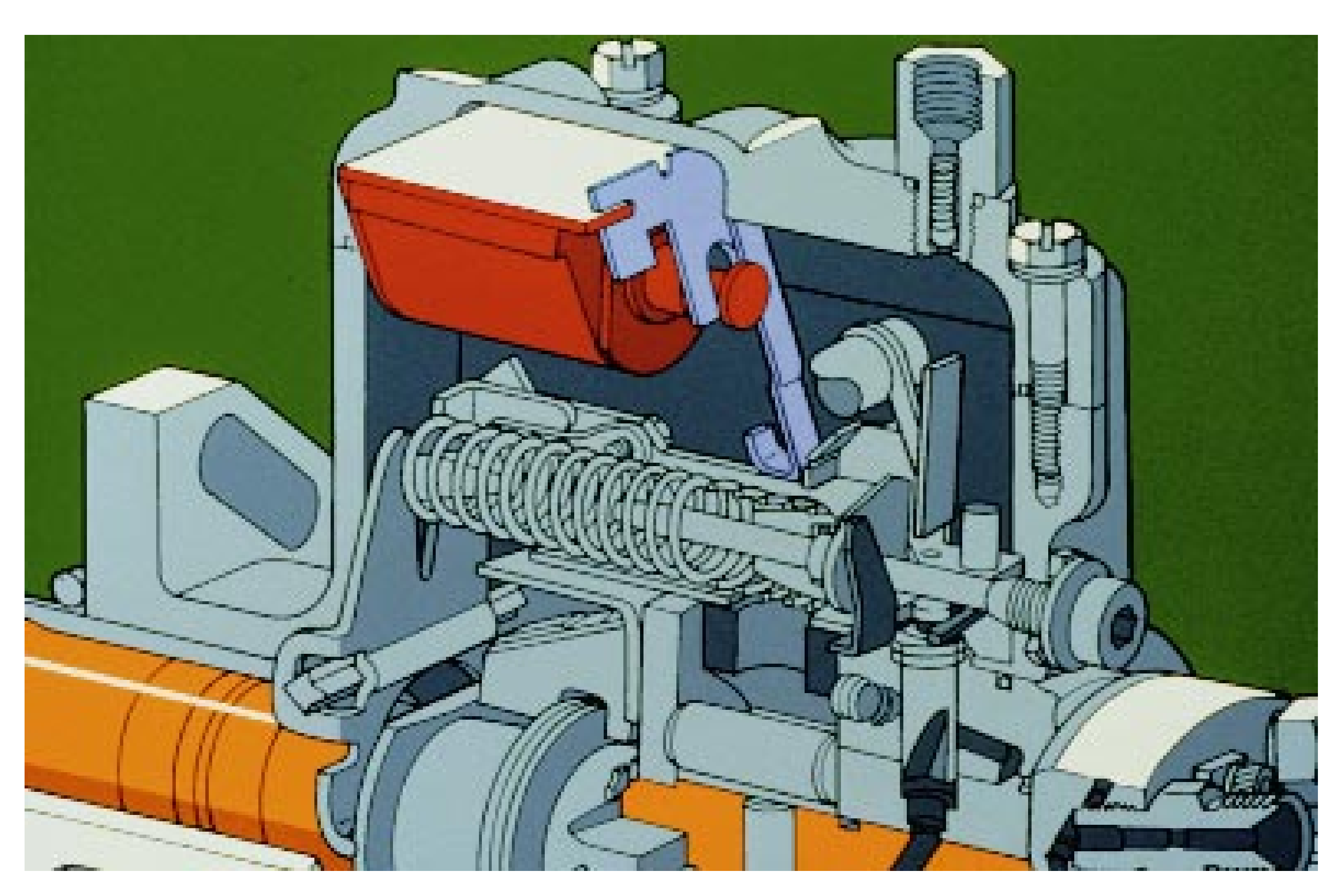
Weights
Thrust Sleeve
Retainer

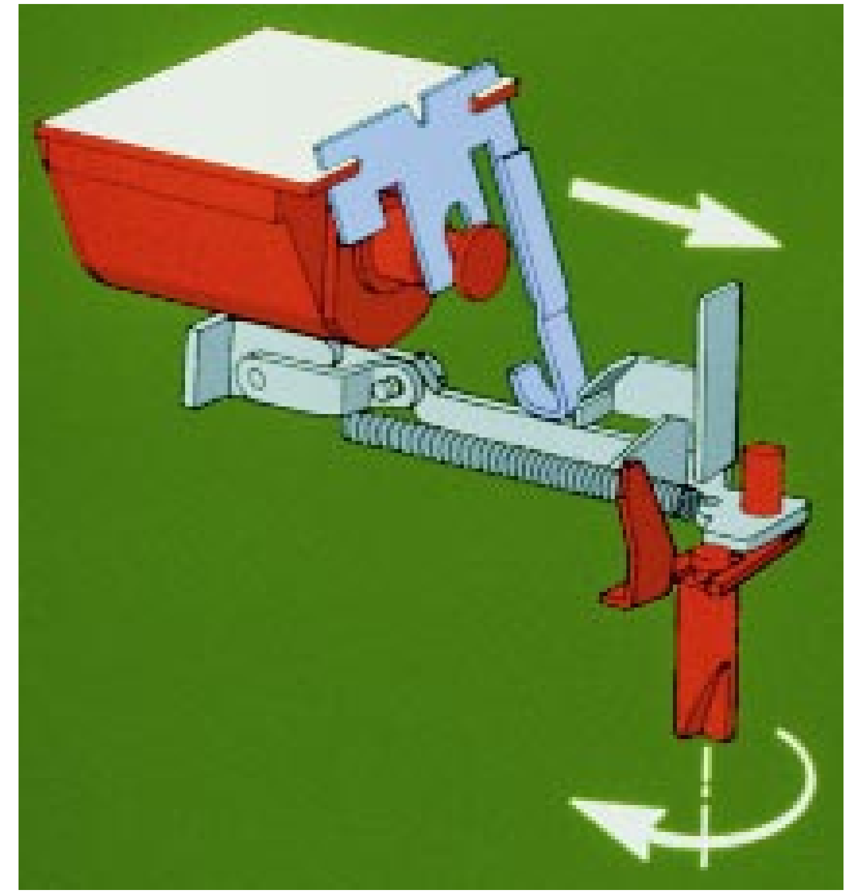

Throttle
Lever
Governor
Arm
Metering
Valve

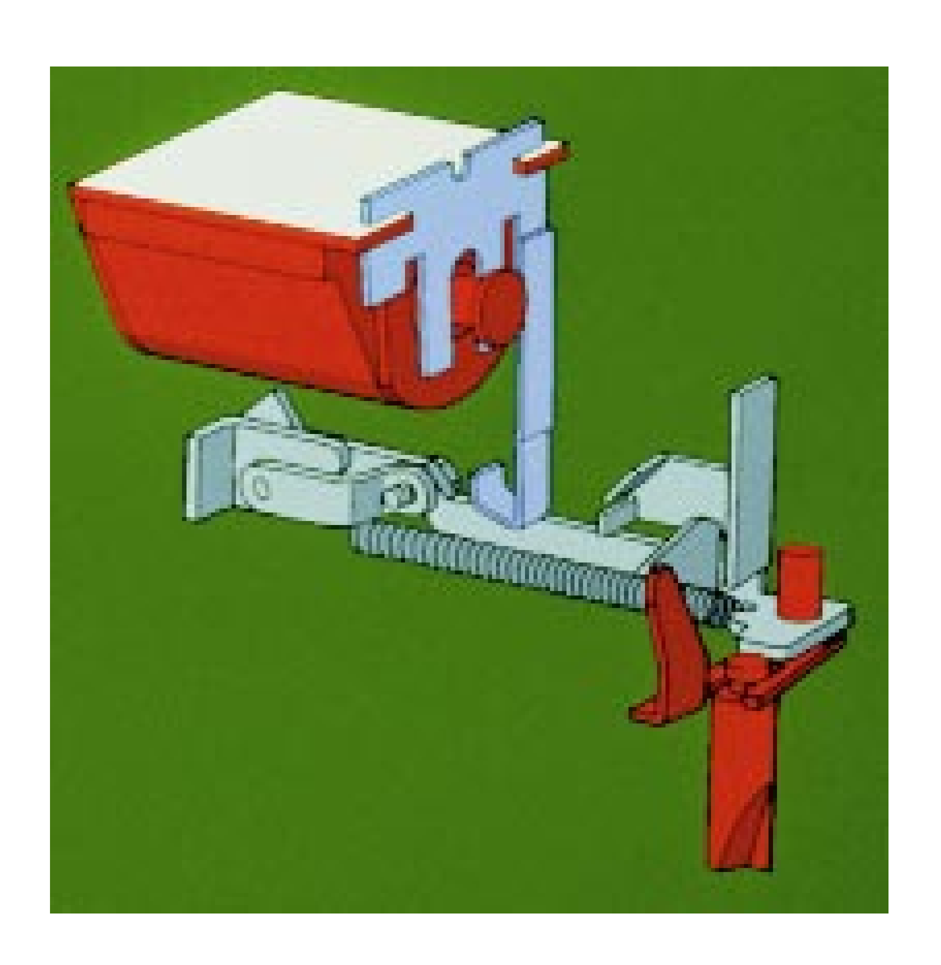



Intake
Manifold
Pressure
Actuator
Fuel Ratio
Control
Lever


Fuel Ratio
Control Lever
Cam
Metering
Valve







Unit injector

Pressure relief valve

Secondary fuel filter elements

Check valve

Filter change valve

Secondary fuel filter elements

Check valve

Relief valve

Main fuel pump

Check valve

Check valve

Hand priming pump

Check valve

Main fuel tank

Primary Fuel filters

TIP COOLING
SPRAY NOZZLE
BARREL
COOLANT IN
COOLANT OUT
FUEL OUT
FUEL IN
RACK
PLUNGER

Input Circuit

Power Circuit

Output Circuit

- Signals From Sensor
- Filter Electrical Noise
- Protect Voltage Levels

- From Battery
(8vdc Minimum)

- To Sensors

- To Rack And Lamps

Eng Data Link Connector

J13

Shutoff Solenoid

Rack Position Sensor

P14 J14

ECM

Rack BTM

Eng Speed Sensor

Atmospheric Pressure Sensor

P15 J15

P7 J7

Boost Pressure Sensor

P8 J8

P17

Coolant Level Sensor

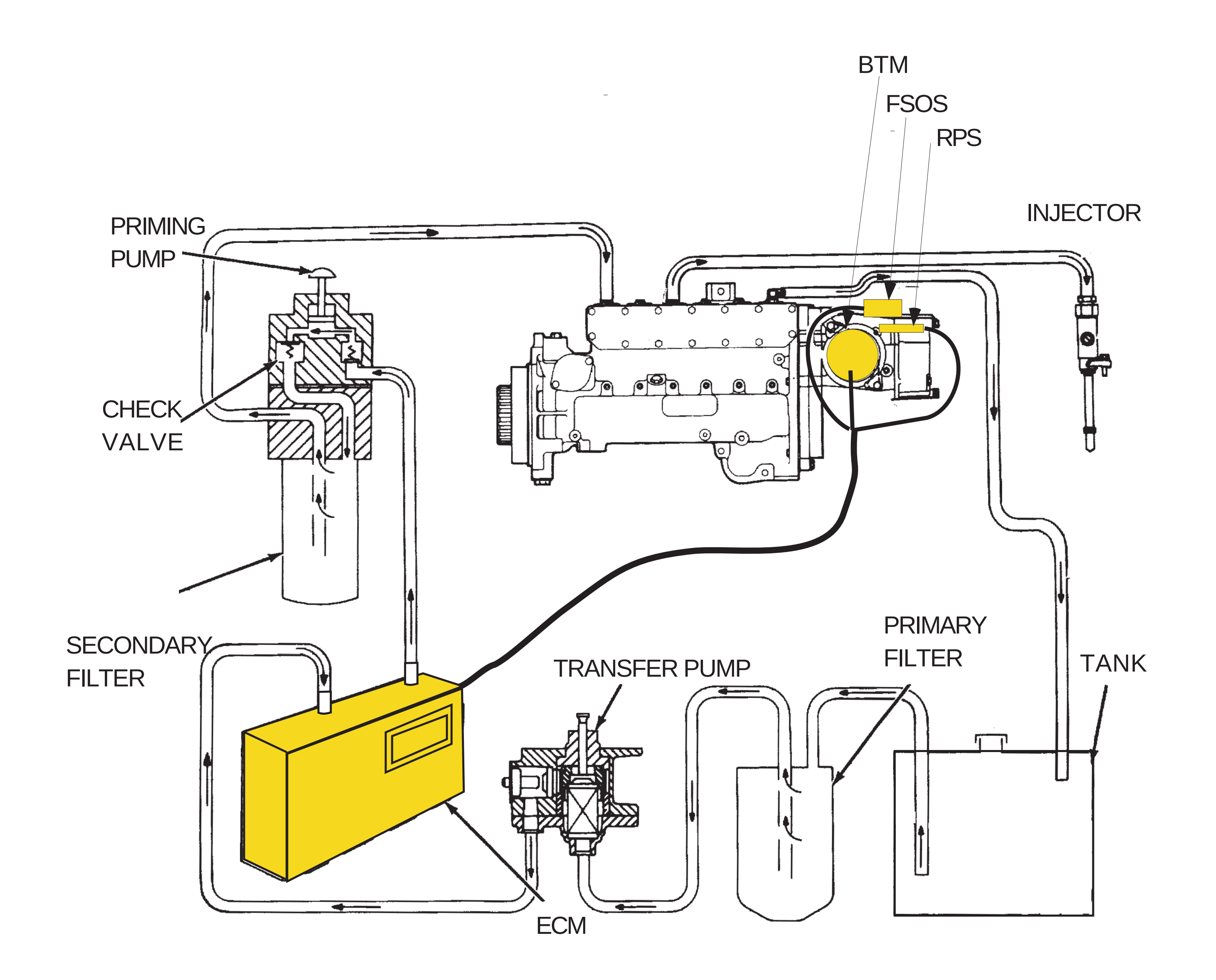
Customer Connector

Oil Pressure Sensor

P9 J9

Coolant Temp Sensor

P12 J12


BTM
FSOS
RPS
INJECTOR
PRIMING
PUMP
CHECK
VALVE
SECONDARY
FILTER
TRANSFER PUMP
PRIMARY
FILTER
TANK
ECM

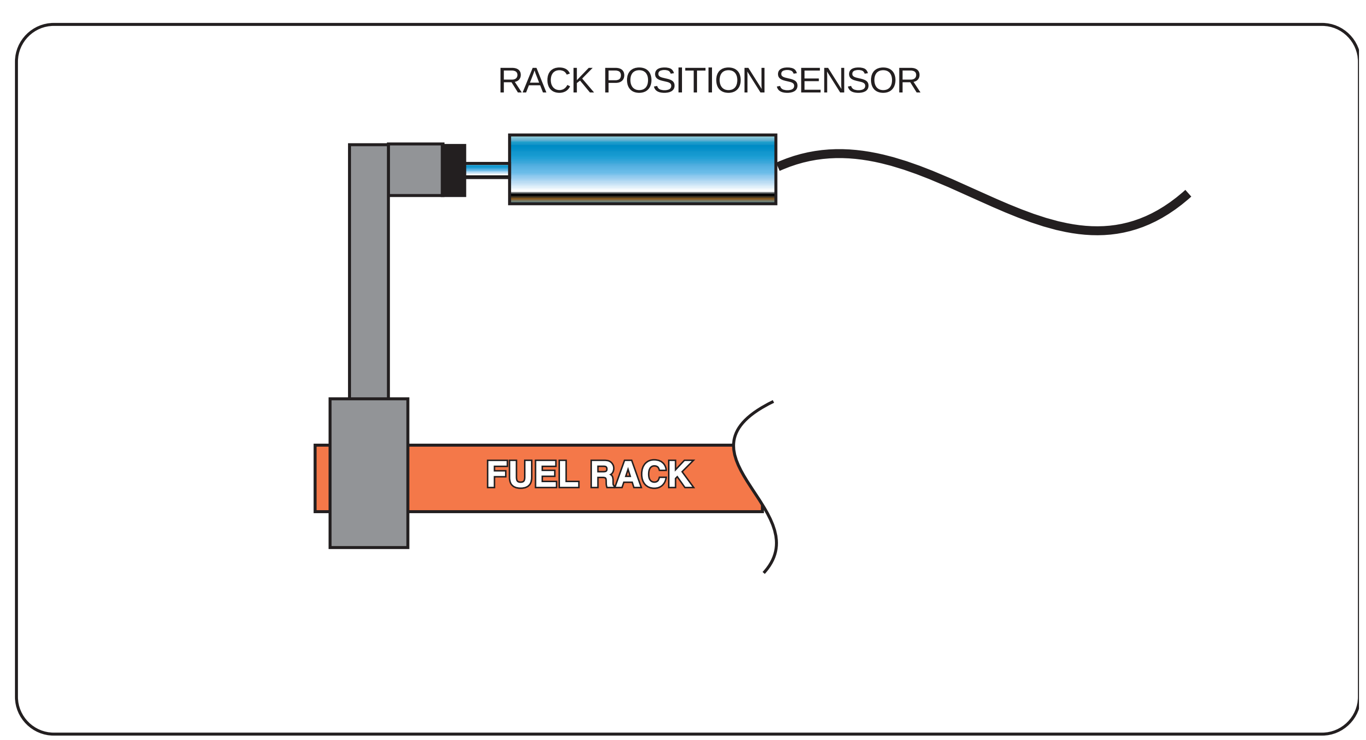
SHUTOFF SOLEINOID

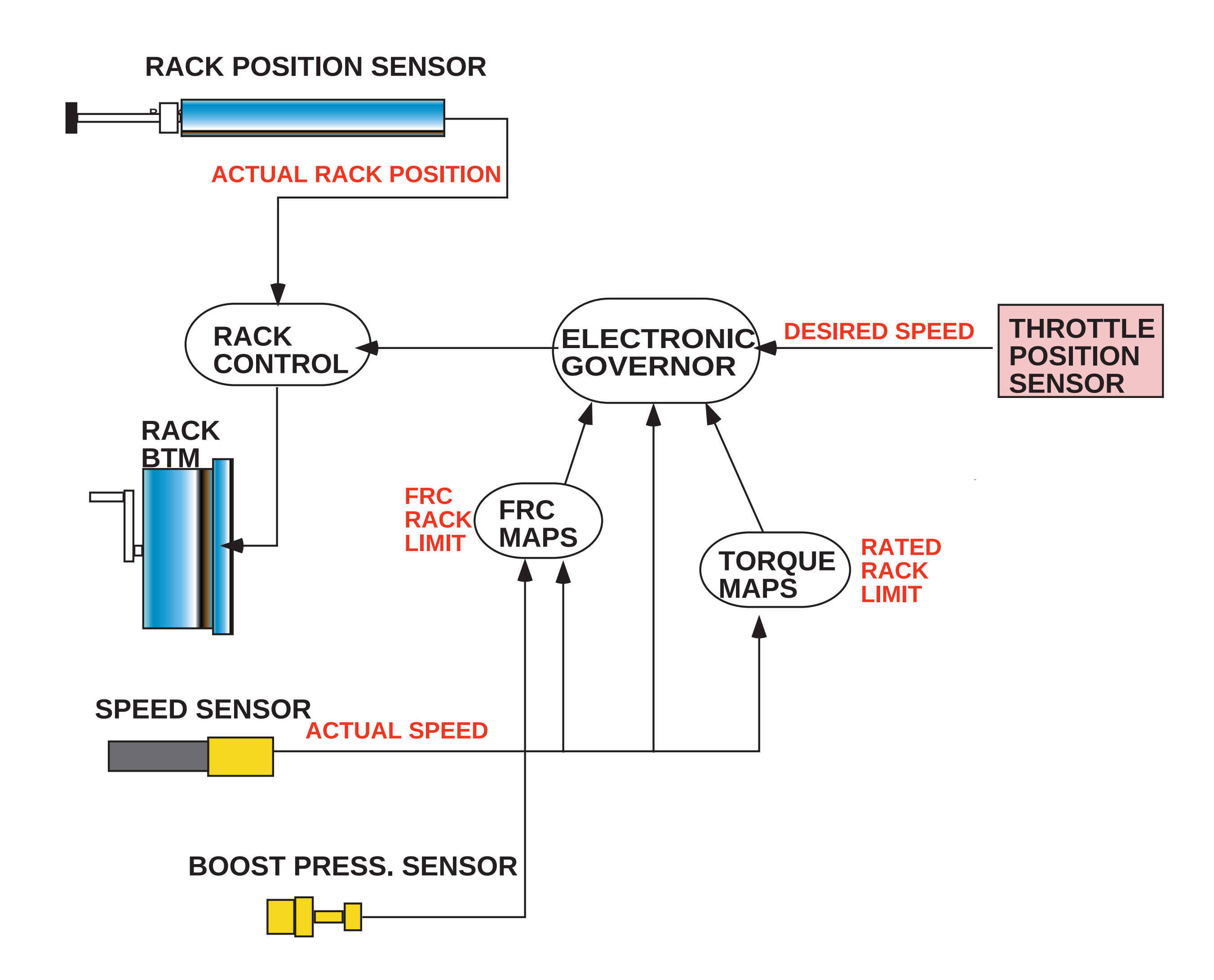
PWM

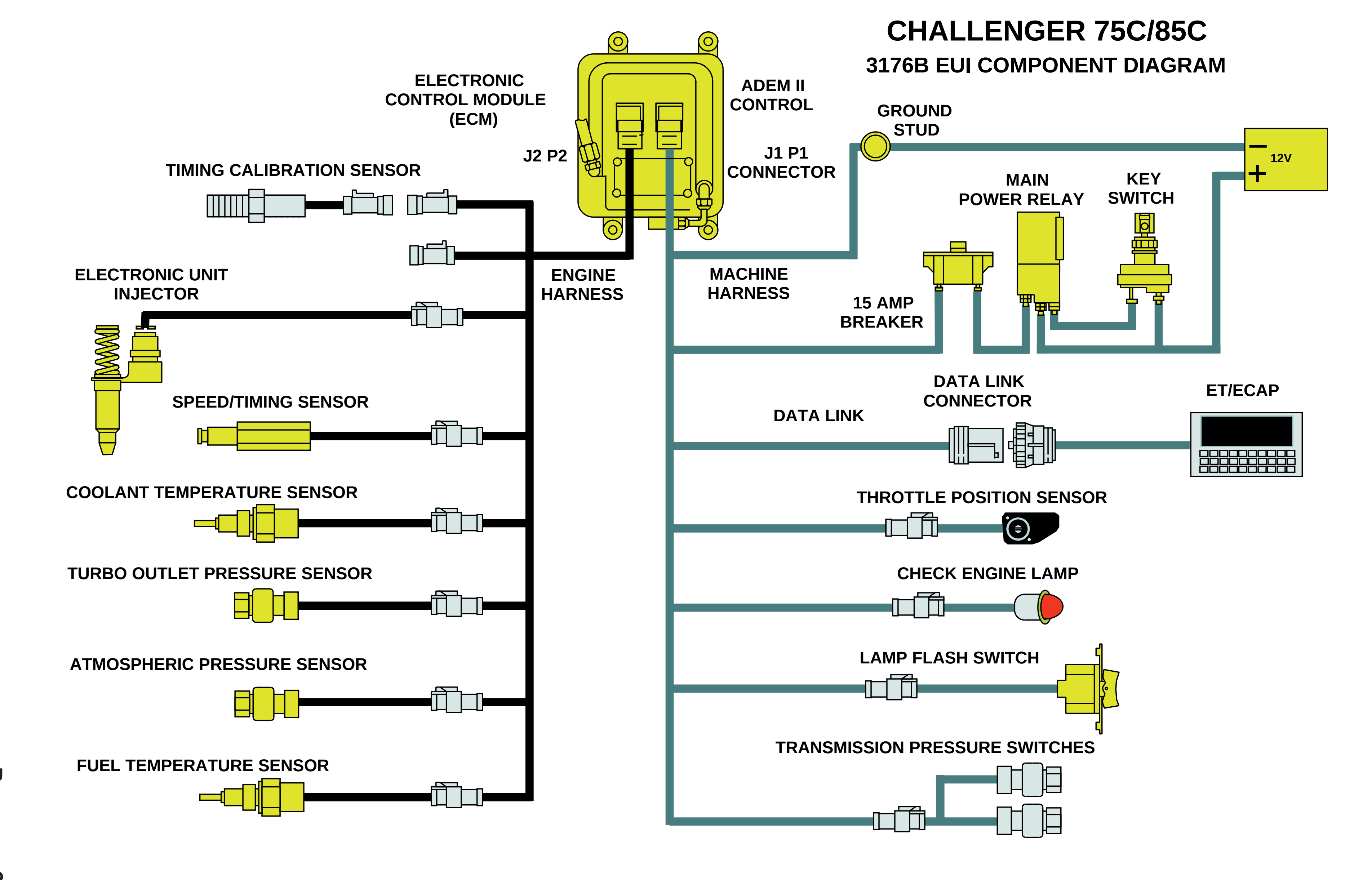
B T M

FUEL RACK SERVO

FUEL ON




RACK POSITION SENSOR
ACTUAL RACK POSITION
RACK CONTROL
ELECTRONIC GOVERNOR
DESIRED SPEED
THROTTLE POSITION SENSOR
RACK BTM
FRC RACK LIMIT
FRC MAPS
TORQUE MAPS
RATED RACK LIMIT
SPEED SENSOR
ACTUAL SPEED
BOOST PRESS. SENSOR


CHALLENGER 75C/85C
3176B EUI COMPONENT DIAGRAM
ELECTRONIC CONTROL MODULE (ECM)
ADEM II CONTROL
J2 P2
J1 P1 CONNECTOR
GROUND STUD
12V
MAIN POWER RELAY
KEY SWITCH
TIMING CALIBRATION SENSOR
ELECTRONIC UNIT INJECTOR
ENGINE HARNESS
MACHINE HARNESS
15 AMP BREAKER
SPEED/TIMING SENSOR
DATA LINK
DATA LINK CONNECTOR
ET/ECAP
COOLANT TEMPERATURE SENSOR
THROTTLE POSITION SENSOR
TURBO OUTLET PRESSURE SENSOR
CHECK ENGINE LAMP
LAMP FLASH SWITCH
ATMOSPHERIC PRESSURE SENSOR
TRANSMISSION PRESSURE SWITCHES
FUEL TEMPERATURE SENSOR

ELECTRONICAL CONTROLED

MECHANICALY ACTUATED

FILTER

RELIEF VALVE

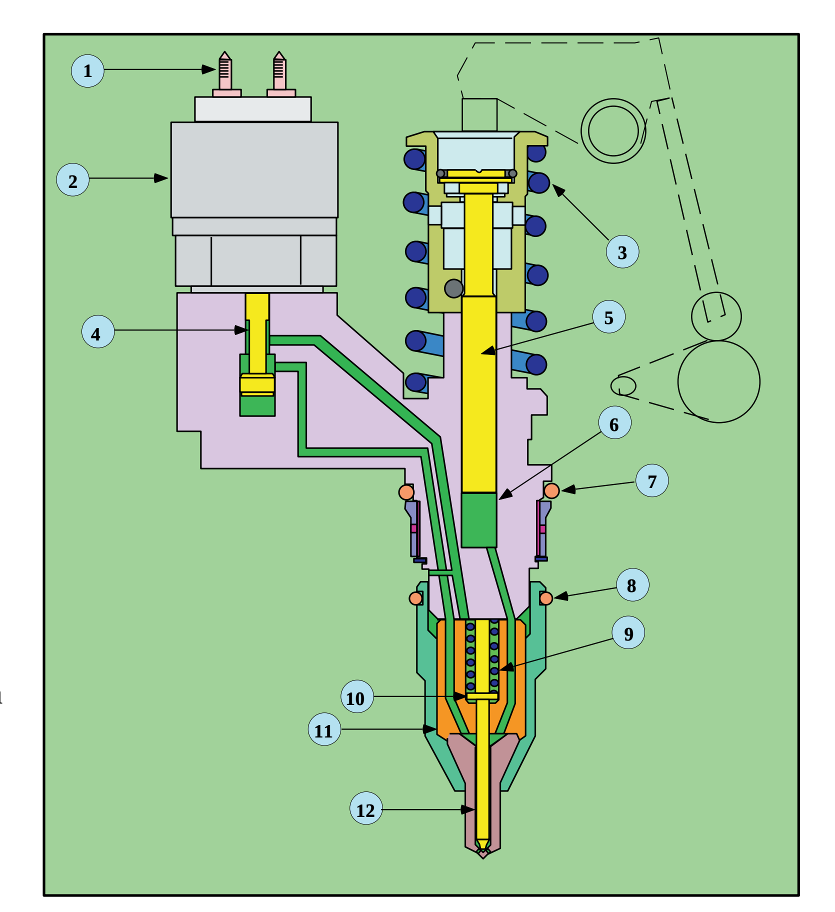
E C M

Electronic Unit Injector

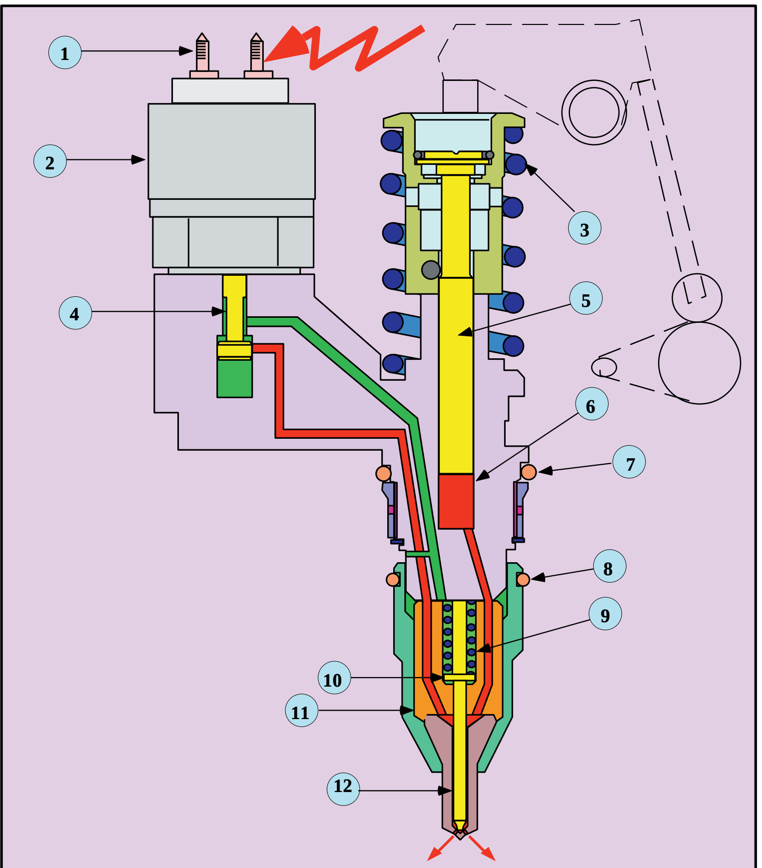
PUMP

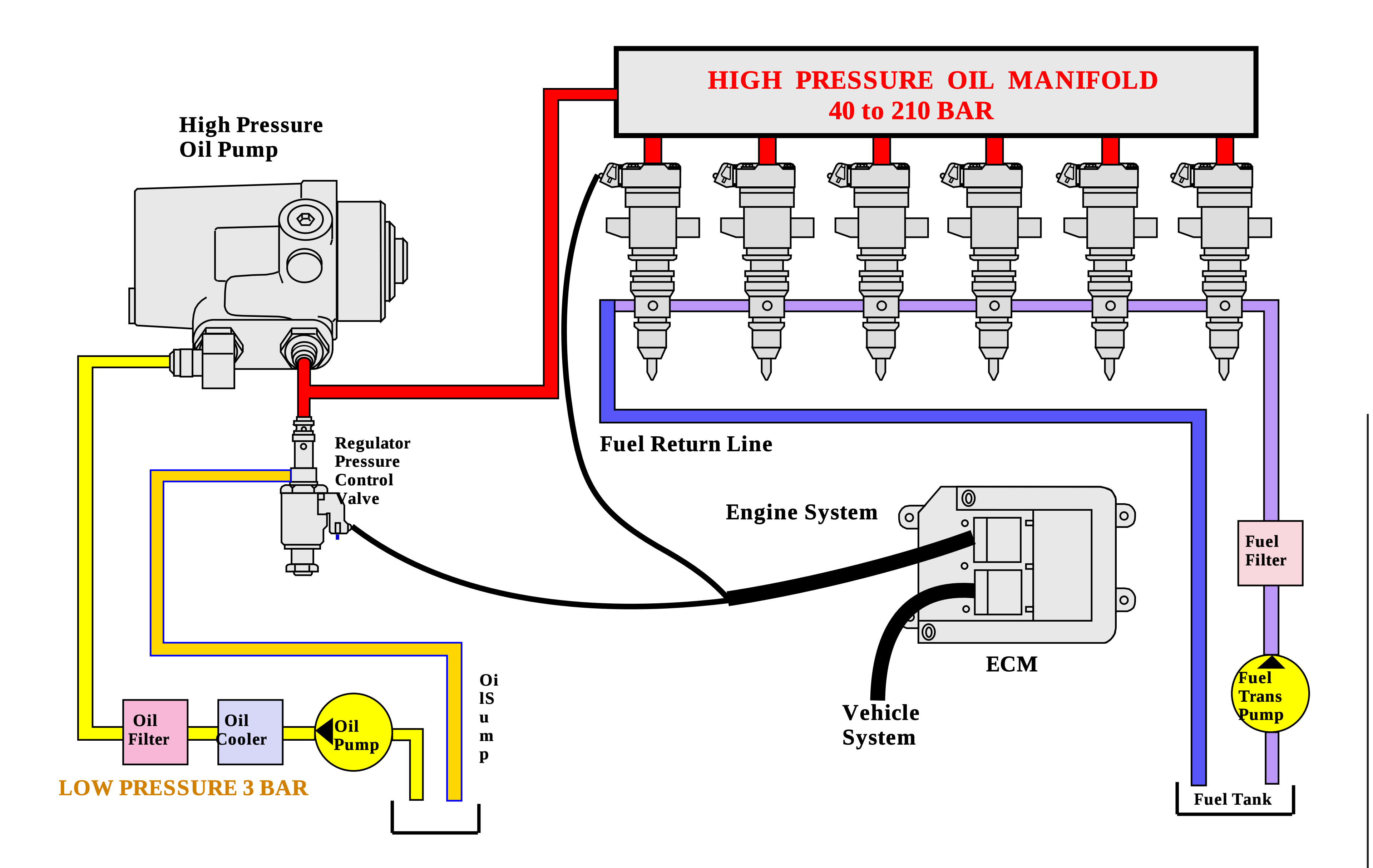
FUEL TANK





1. Solenoid Connection
2. Solenoid Valve Assem
3. Spring
4. Valve
5. Plunger
6. Barrel
7. Seal
8. Seal
9. Spring
10. Spacer
11. Body
12. Check




HIGH PRESSURE OIL MANIFOLD
40 to 210 BAR
High Pressure
Oil Pump
Regulator
Pressure
Control
Valve
Fuel Return Line
Engine System
ECM
Vehicle
System
Fuel
Filter
Fuel
Trans
Pump
Fuel Tank
Oil
Filter
Oil
Cooler
Oil
Pump
Oi
lS
u
m
p
LOW PRESSURE 3 BAR

PRESSURE REGULATING VALVE

HYDRAULIC PRESSURE SENSOR

HEUI

FLUID MANIFOLD HYDRAULIC PASSAGE

FLUID MANIFOLD HYDRAULIC PASSAGE

HEUI

FUEL TEMPERATURE SENSOR

SECONDARY FUEL FILTER

FUEL TANK

ECM

FUEL TRANSFER PUMP

PRIMARY FUEL FILTER WATER SEPARATOR

HYDRAULIC TEMPERATURE SENSOR

OIL PRESSURE SENSOR

COOL DOWN CIRCUIT

PUMP CONTROL VALVE

OIL SUMP

COLD START OIL RESERVOIR

HYDRAULIC SUPPLY PUMP GROUP

TO LUBE SYSTEM

OIL FILTER

OIL COOLER

LUBE OIL PUMP

SPACER

SLEEVE

ARMATURE

VALVE

SOLENOID

VALVE BODY

SHIM

BARREL

ADAPTER

PISTON

WASHER

UPPER FUEL SEAL

PLUNGER

FUEL INLET
CHECK VALVE

PIN

SLEEVE

SPACER

LOWER FUEL SEAL

CHECK

NOZZLE

ARMATURE SCREW

POPPET SPRING

POPPET VALVE

SOLENOID

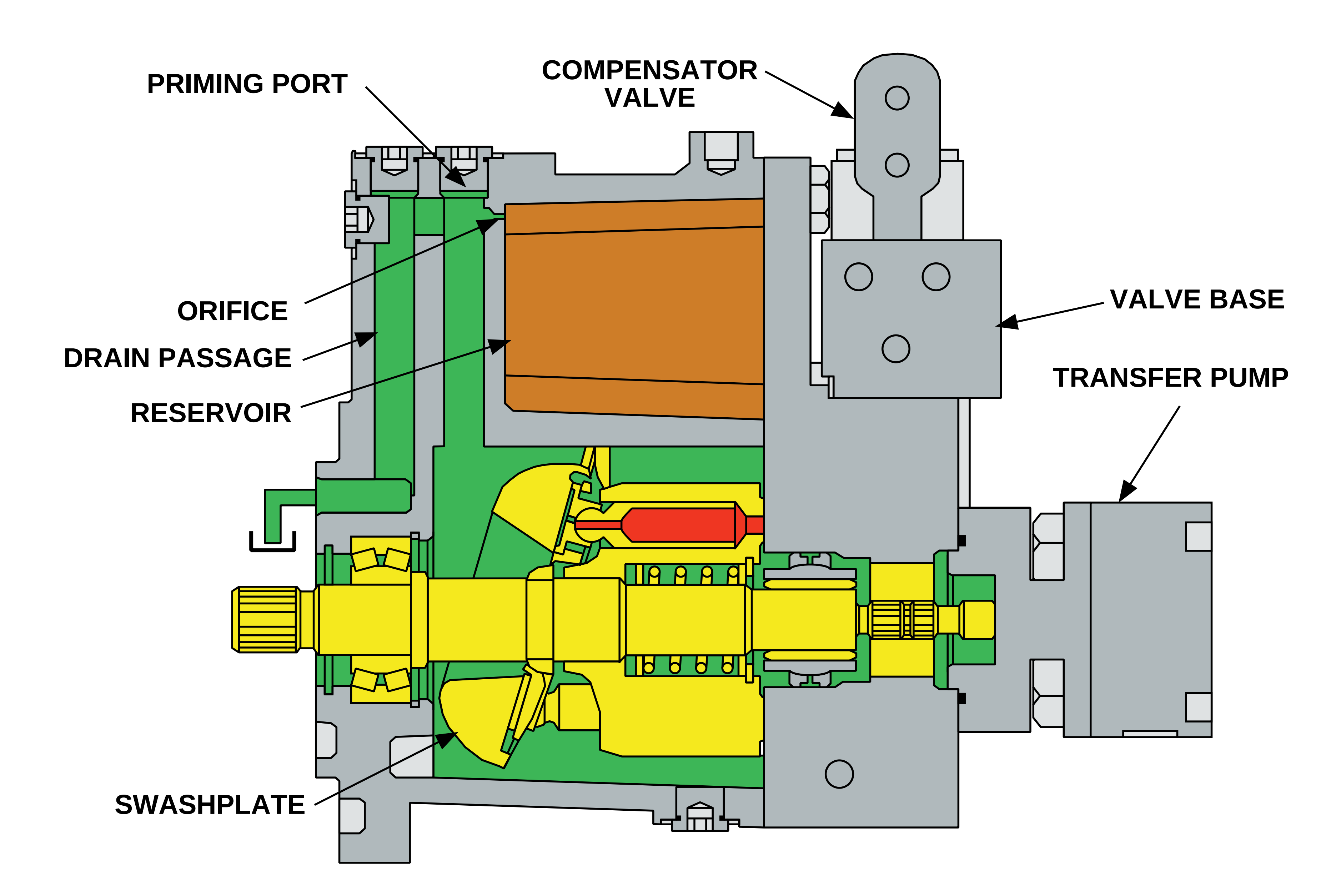
ARMATURE

INLET
VALVE SEAT

EXHAUST
VALVE SEAT

NOZZLE GROUP

CROSS SECTION
OF PLUNGER
START OF INJECTION
PRESSURE DROP
FINAL
PRESSURE INCREASE
INJECTION
RATE
START OF
INJECTION
DURATION
END OF
INJECTION
TIME (MILLISECONDS)


PRIMING PORT
COMPENSATOR VALVE
ORIFICE
DRAIN PASSAGE
RESERVOIR
VALVE BASE
TRANSFER PUMP
SWASHPLATE

INJECTION PRESSURE
HEUI
MECHANICALLY ACTUATED FUEL SYSTEM
IDLE
ENGINE SPEED